REPORT RESUMES

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A GUIDE FOR USE IN DEVELOPING TRAINING PROGRAMS IN VOCATIONAL REFRIGERATION AND AIR CONDITIONING (DOMESTIC).

MISSISSIPPI STATE UNIV., STATE COLLEGE

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THE MATERIAL IN THIS CURRICULUM GUIDE WAS DEVELOPED TO HELP THE INSTRUCTOR TRAIN STUDENTS TO MEET THE ENTRY REQUIREMENTS FOR REFRIGERATION AND AIR CONDITIONING TRADESMEN. EXPERIENCED TEACHERS DETERMINED OBJECTIVES, DEVELOPED A JOB ANALYSIS, IDENTIFIED THE INSTRUCTIONAL CONTENT, SEQUENCED LEARNING EXPERIENCES, AND SELECTED PERTINENT LITERATURE. THE WORK WAS COMPILED, EDITED, AND EXTENDED BY THE STAFF OF THE CURRICULUM MATERIALS LABORATORY. MAJOR DIVISIONS ARE FUNDAMENTALS AND GENERAL SHOP, CONVENTIONAL DOMESTIC REFRIGERATION, AND RESIDENTIAL AIR CONDITIONING. TEACHING UNITS WITHIN DIVISIONS CONTAIN REFERENCES, TRADE KNOWLEDGE, JOB ASSIGNMENTS, SAFETY PRACTICES, TOOLS, EQUIPMENT, SUPPLIES, PROCEDURES, AND TIME ALLOTMENTS. THE 1,080-HOUR COURSE IS FOR GROUP INSTRUCTION TO GRADE 11 AND GRADE 12 STUDENTS WHO HAVE MADE A DEFINITE VOCATIONAL CHOICE. THE INSTRUCTOR SHOULD HAVE AT LEAST 2 YEARS TRADE EXPERIENCE BEYOND THE LEARNER'S LEVEL AND BROAD EXPERIENCE IN THE OCCUPATION. THE APPENDIX CONTAINS -- (1) RECOMMENDED TEXTS, (2) INSTRUCTOR'S REFERENCES, (3) THE JOB ANALYSIS, (4) AN EQUIPMENT LIST, (5) A BIBLIOGRAPHY, AND (6) OUTLINES OF RELATED BASIC MATHEMATICS, PHYSICS, AND CHEMISTRY TO BE TAUGHT. THIS DOCUMENT IS AVAILABLE FOR $2.00 FROM CURRICULUM LABORATORY, BOX NU, STATE COLLEGE, MISSISSIPPI 39762. (HC)

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A Guide
in
Vocational
REFRIGERATION & AIR CONDITIONING
– Domestic –

PRELIMINARY DRAFT -- FOR DISCUSSION ONLY

Prepared and Issued by the
CURRICULUM LABORATORY
TRADE AND TECHNICAL EDUCATION
STATE DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION
Jackson, Mississippi

Located in the
DEPARTMENT OF INDUSTRIAL EDUCATION
MISSISSIPPI STATE UNIVERSITY
State College, Mississippi

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A GUIDE

For Use in Developing Training Programs

in

VOCATIONAL REFRIGERATION AND AIR CONDITIONING (DOMESTIC)

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FOREWORD

A competent tradesman in the field of Refrigeration, Air Conditioning, and Heating must have a strong foundation in the basic principles of electricity, refrigeration, and air conditioning. This background enables the tradesman to make installations of equipment and control circuits. It will also enable him to diagnose malfunctions and make the necessary repairs.

Instruction of all students as a single group is recommended for most of the fundamental section and for other areas where it is applicable. The informal lecture-demonstration method is likely to be the best approach in this type of instruction. Laboratory experiments and applications will be performed by paired students at workbenches. Each workbench should be equipped with standard tools for the refrigeration, air-conditioning tradesman. Additional tools, special equipment, and necessary supplies will be issued by the instructor as needed.

The need to familiarize the student with safety practices and with the use and care of hand tools is very important. Instruction in principles, safety practices, and the use of additional hand tools should immediately precede their application.

Fundamentals and general shop, conventional domestic refrigeration, and residential air conditioning are the three major divisions of the guide. This guide emphasizes the domestic, rather than commercial, equipment because the size, expense, and complexity of commercial equipment make an extended program impractical for the beginner. Moreover, a student who has sufficient background in domestic refrigeration and air conditioning is employable and should be able to acquire a knowledge of commerical equipment through experience and by furthering his education on his own initiative.

A major portion of the student's time should be invested in manipulative trade experiences. These experiences or shop activities are designed to simulate industrial problems. The student should be involved in planning and installing equipment and controls. The ability to diagnose and repair operating circuits, equipment, and controls is essential. The new types of equipment and controls that are constantly being introduced require a high level of skill and technical knowledge on the part of those called upon to install and maintain the various systems and components.

The importance of mathematics and scientific principles for the tradesman can hardly be overemphasized. The application of these principles must be given by the trade teacher as part of the trainee's instruction. In the outline of instruction, sufficient time has been allotted throughout the entire two years to permit adequate presentation of mathematics and science without sacrificing experiences in the development of trade skills.

Each section of the outline begins with a list of references and of equipment selected to assist the teacher in presenting his material and in enriching his instruction. These lists have been carefully chosen and should prove invaluable if used consistently. Usually, there is one reference to material from Louisiana. This material, when used as a guide, will be especially helpful as the teacher prepares his own job sheets and other instructional material sheets necessary for his work as a teacher.

ACKNOWLEDGMENTS

A Curriculum Conference, held on the campus of Mississippi State University September 22, 23, and 24, 1966, formulated plans for the training of air-conditioning and refrigeration tradesmen in the Type B Shop. The conferees determined the objectives and the limits of the training, developed a job analysis, identified the instructional content, sequenced learning experiences, selected pertinent literature from a considerable volume of material. Among those who attended the conference and pooled their knowledge and experience to advance the program were the following instructors and the institutions they represent:

C. N. Dickerson	Holmes Junior College
Moffitt Gentry	Northeast Junior College
Horace Goodman	Ross Collins High School
Carl Majors	Northwest Junior College
Jack H. Rice	Hinds Junior College
C. O. Scofield	Jefferson Davis Junior College
William E. Thurner	Ross Collins High School
Joe Westmoreland	Tupelo Attendance Center
Charles F. Williams	Hinds Junior College

Also assisting at the conference was H. D. Tatum, who was a teacher of electricity for many years. Mr. Tatum is now an equipment specialist with the State Department of Vocational Education, Trade and Technical Section.

Following the conference, the staff of the Curriculum Materials Laboratory at Mississippi State University compiled, edited, and extended the work of the conference; added a description of the Type B Shop and of the air-conditioning and refrigeration tradesman's job; which is included in this publication.

TABLE OF CONTENTS

Page

Foreword ii

Acknowledgments iv

To the Instructor vi

Vocational Refrigeration and Air Conditioning Mechanic (Domestic) ix

Characteristics of Trade Training x

COURSE OF STUDY

Course Description 3

General Shop and Fundamentals of Electricity 4

Domestic Refrigeration 48

Domestic Air Conditioning 75

A Word of Explanation 91

APPENDIX

Recommended Texts and Key for Instructor's References 92

Related Mathematics 94

Related Science 96

Training Analysis 100

Equipment, Tools, and Supplies 105

Bibliography 117

TO THE INSTRUCTOR

Introduction

The purpose of trade training is to prepare persons for entry into a specific trade. To accomplish this, the instructor guides each trainee in the development of knowledges and skills of his trade. The instructor uses teaching methods and instructional materials as tools, much as he uses the tools of his trade to perform specific tasks. His skill as a teacher and as a tradesman depends upon his ability to use these tools.

A full treatment of the role of the Curriculum Materials Laboratory in implementing the foregoing process is contained in the Operational Plan. Simply stated, the Laboratory provides technical assistance to state and local educators in improving instruction through the development of instructional materials, and communicates with industry about training being offered.

The first step

Since the accepted practice in trade training is the identification of the knowledges and the skills of the trade, the Laboratory asked Mississippi trade instructors to supply information. The process described in the FOREWORD was used in arranging the information in a teachable form. It is an instructional base and is usually referred to as a course outline or guide. Its proper use requires skillful applications of teaching methods as tools in presenting the content of the outline. The end result is a trainee who is skilled and knowledgable.

Since this publication is the instructional base for the teaching of a specific trade, all future work will be planned around this base. Workshops will be held to develop supplementary instructional materials for use by the trade instructor in enriching his program.

Characteristics of this publication

First, its scope, in terms of content, is broad and applicable in all parts of the state. The instructor, who directs his class in becoming proficient with each of these knowledges and skills, assists each student in meeting beginning employment standards. The student is prepared to take advantage of opportunities for gainful employment in any part of the state.

Second, while the scope of the program is broad and there is depth, an effort was made to confine the content of the outline to those knowledges and skills essential to occupational entry. This policy allows the local instructor to supplement his program with additional experiences. Although identifying only essentials, this publication encourages local insitiutions to seek and to offer the special instruction which will meet regional industrial needs.

Third, a serious effort has been made to arrange the content in a usable form. The elementary knowledges and easiest tasks precede more difficult ones. Assignments are written in a step-by-step fashion. All content has been carefully sequenced. Time for instruction in class and in shop is listed in approximate terms.

Fourth, as indicated by certain items in the format, this publication is designed for the Type B Shop found in Mississippi secondary schools. However, it should not be inferred that this is its only valid use. The content and sequence are equally applicable to trade training in junior colleges and in MDTA programs or in any preparatory program.

The impact of this publication

What then should be the impact of this publication on the local program? Since the purpose is to encourage a planned, orderly, more efficient instructional program, it must be used and evaluated by the instructor. He should give this publication his best efforts in light of the principles and practices of trade training. Examination, evaluation, and recommendation during preparation of instructional materials and while teaching from them will assist in continued program development. Using this publication as a guide, the instructor should make lesson plans for lectures and demonstrations and should prepare shop activities. In some instances, the instructor will likely find more information and in greater detail than he is presently using. There may be more than one job assignment. In other instances, the development of an idea may appear to shallow or a job may be absent. It is at this time that the instructor can be most helpful in the following ways: (1) by suggesting which areas can be effectively covered in a shorter time, (2) by identifying areas requiring greater emphasis, which would involve additional detail and an extended time allocation, (3) by extending the instructional content to reinforce or clarify ideas, (4) by preparing additional or alternate jobs, (5) by listing references, texts, and instructional aids at appropriate places, and (6) by suggesting additions and deletions.

Some of the suggestions listed above may require only marginal notes; others may call for development of completely new and more comprehensive materials. The result will be realistic evaluation of content, organization, and time allotment for each unit.

Purposes and characteristics not inferred

As previously stated, this publication is intended to assist in improving instruction. It is planned, items are sequenced, and time limits are set because these characteristics are the heart of a strong instructional program, and for no other purpose. Consequently, it should not be inferred that this publication is an exact image of any given program. As noted earlier, local institutions go well beyond these minimum requirements to enrich their programs.

Also, it is not expected that every institution's program be exactly like every other program, that hour allotments be rigidly adhered to, or that students be rotated on a clockwork or calendar basis. On the contrary, the emphasis is on individual proficiency. It is likely that students of lesser ability will require longer periods in certain areas. These students may gain only the minimum proficiencies, while more able students will progress rapidly and engage in many enriching experiences. Consequently, the planning, sequencing, and allotting are not designed to standardize programs, but to assist local teachers in planning more carefully and conducting their instruction more effectively.

Evaluation

Finally, recent vocational-technical legislation contains provision for follow-up and program evaluation. The day is coming when vocational-technical education will be held accountable for its actions in training youth and adults and for the millions of dollars it has spent. The Curriculum Materials Laboratory will, no doubt, be involved in developing suitable instruments and evaluative criteria at that time. This publication, representing the combined efforts of Mississippi education and industry and containing the material these groups consider appropriate, may well serve as one basis for making such a study.

VOCATIONAL REFRIGERATION AND AIR-CONDITIONING MECHANIC (DOMESTIC)

The tradesman who undertakes a job of refrigeration and air conditioning must be able to perform a number of mechanical duties singly or in total. He reads blueprints or schematic drawings to determine location, size, capacity, and type of components, such as compressor, condenser, valves, and tubing or piping needed to build or repair a refrigeration system. He mounts compressor, condenser, and other components in specified locations of frame, using hand tools and acetylene welding equipment, using knowledge of metal properties. He cuts, brazes, and bends specified tubing to inlets and outlets of components to form liquid and suction lines of the refrigeration system. He installs expansion and control valves, using acetylene torch and wrenches; adjusts valves according to specifications; removes air from system and charges system with specified amount of refrigerant; attaches thermocouples to various points of refrigeration system; and test-operates equipment to evaluate functioning and cooling capacity of the system. He records pressure and temperature readings from gages and temperature potentiometer during test run, and then compares his readings with specifications to evaluate performance of the system and to adjust or replace parts as indicated.

He observes functioning of components such as controls, fan, condenser, evaporator, or compressor to determine need for repairs or replacement. He drains oil and pumps gas from unit; loosens bolts and melts solder or brazed seams to dismantle unit, using hand tools and torch; removes and replaces defective components; assembles unit by bolting, soldering, brazing, using measuring instruments, hand tools, soldering iron, and hand torch.

An air-conditioning mechanic services and repairs domestic air-conditioning units, usually ranging from 1/2 to 2 tons capacity in private residences and small business establishments. He examines the unit visually for defective parts or determines cause of malfunction by listening to machine in operation, utilizing knowledge of mechanical, electrical, and refrigeration theory. He dismantles the whole unit or part of it, as indicated by type of malfunction, and repairs or replaces such parts as switches, relays, fan motors, thermostats, and other components, using hand tools and power tools. He replaces filters, lubricates unit, and adjusts controls; reassembles machine, making necessary adjustments to insure efficient operation. He may estimate cost of repairs or adjustment; may remove machines from customers' premises for major repairs or overhaul in shop, or for return to manufacturer for more extensive repairs. And he may install air conditioners.

An additional Description can be found in the Dictionary of Occupational Titles - Third Edition, under AIR-CONDITIONING--MECHANIC, DOMESTIC (any ind.) 637.281. Air-conditioning-window-box serviceman, also REFRIGERATION MECHANIC (any ind.) 637.281. Air-conditioning attendant; air-conditioning mechanic; refrigeration-equipment erector, and REFRIGERATION UNIT REPAIRMAN (refrigerat. equip.) 637.381.

CHARACTERISTICS OF TRADE TRAINING

Introduction

Training for various trades without on-the-job experience can be and is being given effectively by simulating, in locales other than industrial plants, an on-the-job environment. The industrial environment is achieved in an educational institution by performing jobs of fabrication and service using industrial techniques and industrial-type equipment and facilities. The additional requirements placed upon the training as a result of its operating within an institution have been successfully met. It has proved advantageous to all concerned to provide preparatory training for qualified students and extension training for employed tradesmen. Characteristics of institutional training are briefly described in the following paragraphs.

Physical Facilities, Equipment, and Supplies

As previously stated, trade-training facilities must be designed and constructed so that they lend themselves to fabrication and service operations found in industry. Built-ins are provided with adequate floor space, lighting, climate control, power sources, entrances, equipment, storage for supplies, finished-product handling, waste-disposal systems, etc. --each of which is duty-rated to serve its purpose in an industrial manner. That costs and floor-space requirements per pupil are higher than those for general education are facts that must be recognized because they are intrinsic in the nature of the training and cannot be side-stepped. Equipment and supplies must meet the standards of quality and variety used in industry, and they must be maintained and replenished.

Instructor Qualifications

Of equal importance is the caliber of the instructor. Past experience has assisted in establishing the requirement of at least two years of work experience beyond the learner's level, in the specific training being given, and of broad experience in the major areas of the industrial occupation. The instructor must be adept in selecting, organizing, and presenting trade information and skills--a fuller treatment of which may be found in later paragraphs. The trade teacher must also keep himself occupationally up to date through study and association with industrial activities.

Student Screening and Selection

The State Plan states that any student who wants, needs, and is able to profit by instruction is eligible for enrollment in vocational training. His ability to profit by the instruction depends, in large measure, on his making a definite vocational choice, his desire to gain the knowledges and skills of the trade, and his educational background. These qualifications are evaluated, insofar as is possible, by a vocational-guidance process which includes an examination of the applicant's school record, a personal interview, a check of references, and tests for interests, motivations, and learning rates; and, in the absence of adequate guidance facilities and a screening process, it is reasonable to expect that a considerable number of those accepted for training will need remedial instruction in science, mathematics, and communication skills.

In Mississippi, preparatory training is offered in the Type B Shop located in the comprehensive high school. Trade training is carried on 180 days per year. Normally, the course is elected for both the junior and the senior years. In two years a student receives 1080 hours of instruction. However, some students enroll for the senior year only. Although these students receive no more than minimal experiences, instruction on a planned rotational basis will provide them with knowledges and skills in the basic blocks of the trade and will render them employable.

Teaching Techniques

Trade training uses most, if not all, of the conventional teaching techniques and adapts them to the information to be presented. The "tell-show-do-check" method has been found highly effective and is the one most commonly used. The instructor "tells" by informally lecturing on a given topic. Open periods of discussion allow the student to clarify points not initially grasped. The instructor may choose to stimulate thought or to spot-check comprehension by questioning. The "show" method is employed when a demonstration can more vividly present a principle or the steps of trade procedure. Specially prepared audio-visual aids may be involved to "show". The major investment of time is on the "do", where the student is engaged in useful and productive work in typical trade jobs. He uses tools, equipment, and materials common to the trade. Thus he learns by doing. At predetermined intervals, a "check" of the student's progress serves to evaluate command of knowledge and skill learned to date. Deficiencies identified are retaught through additional, individual instruction, through reading, shop practice, etc., until an acceptable level of learning and performance is reached.

Related Instruction

The value of scientific principles and mathematical applications for the tradesman is unquestioned. Indeed the caliber of his work in these areas is determined by the quality of his foundation in these principles and his ability to apply and adapt them. However, trade trainees, characteristically, react to mathematics and science with disinterest when these subjects are presented on the academic level with the usual academic approach. But these subject areas become much more acceptable when they are applied to the job in which the trainee expects to develop skill and earn a living.

In the Type B Shop, no outside instruction related to the trade is given.

The shop teacher is expected to meet the need. Upon him rests the responsibility of supplying any and all necessary teaching of trade mathematics, trade science, trade drafting, etc. This information is also correlated with trade practice and given as needed by the student.

Group instruction and group shop activity are encouraged when space and equipment are available, for it is generally conceded that instruction of the typical class as a group is an advantage for the progress of the class. Extensive preparation prior to group instruction and keen observation of individual behavior are necessary to meet the variety of need and speeds in a heterogeneous class. The volume of trade tools, equipment, and materials, as well as adequate space and shop facilities required for the instruction of large groups, makes the costs prohibitive in many instances; and a scheduled rotational process must be employed. A suggested plan is found in the Appendix.

Instructional Content

The source of the instructional content of a given trade program can come only from the trade itself; that is, from the knowledges and the skills of the master. Usually a trade analysis is used to identify this content. Following the analysis, there is much need for proper organization and preparation prior to presentation of the material. An extension of this characteristic of the program is the establishment and maintenance of an up-to-date reference library in the classroom-shop. Materials housed here are found in many forms, such as textbooks, technical manuals, trade periodicals, manufacturers' catalogs, safety bulletins, etc. All of them should be shelved in a systematic arrangement with a careful record kept for ready reference.

Safety Instruction

The place and value of safety instruction cannot be overemphasized. The instructor is morally and legally responsible for introducing safety instruction prior to performance, for using safe techniques in demonstrations, and for tactfully, but firmly, pointing out each violation.

Summary

In summary, trade training can be characterized as instruction in trade practices given by an occupationally competent teacher. Related information is carefully correlated with shop activities and is given by the trade teacher as it is needed by the trainee. Students who have made a vocational commitment, and who are able to profit by the instruction are engaged in productive learning experiences. Successful completion of such a program prepares a student for employment at an advanced-learner level.

COURSE OF STUDY

GENERAL SHOP AND FUNDAMENTALS OF ELECTRICITY

COURSE DESCRIPTION

Vocational Refrigeration, Air Conditioning, and Heating is designed to help the learner develop employable skills in the trade. Manipulative skills, such as soldering, brazing, wiring, and other skills that are used in the repair and installation of equipment are stressed. Analyzing domestic refrigeration and air conditioning systems is one of the most important phases included in the course.

Time has been allotted so that the instructor may include the necessary related subject matter, such as mathematics, science, and safety. An outline of mathematics and science is included in the appendix of this guide to help the instructor identify these areas.

INSTRUCTIONAL BLOCKS

	Contact Hours
FUNDAMENTALS AND GENERAL SHOP	400
REFRIGERATION	400
AIR CONDITIONING	280
Total Contact Hours	1080

INTRODUCTION TO REFRIGERATION, AIR CONDITIONING, HEATING

Time 5 hours

Trade Knowledge

References

1. Opportunities
    a. Industrial
    b. Commercial
    c. Domestic
2. Growth of the various phases
3. Overview of course
    a. General course content
    b. Related course content

Trade Practice

Job

Practice the use of safety precautions and first aid

Safety

Tools, Equipment, Supplies

Procedure

1. Introduction to safety
2. General ground safety
3. Accident causes
4. Work area safety practices
    a. Housekeeping
    b. Horseplay
    c. Improper working methods
    d. Safety color codes
    e. Danger tags
5. Fires and fire prevention
    a. Fire prevention
    b. Classes of fires
    c. Portable fire extinguishers
6. Electrical hazards and safety practices
    a. Effects of electrical shock
    b. Electrical maintenance
    c. Electrical fires
7. Compressed gases
    a. Care of refrigerant cylinders
    b. Care of oxyacetylene cylinders
8. Introduction to first aid
9. Specific types of wounds
    a. Stopping bleeding
    b. Application of tourniquet
    c. Prevention or treatment of shock
    d. Protection of the wound

10. Fracture and severe burns
    a. Arm fractures
    b. Fractures backs
    c. Leg fractures
    d. Hip and thigh fractures
    e. Treatment of burns
    f. Broken necks

11. Treatment for electrical shock
12. Artificial respiration
    a. Exhale air method
    b. Back pressure - arm lift method
    c. Back pressure - hip lift method

13. Emergencies from toxic substances
    a. Fuels
    b. Gas vapors

II. BASIC ELECTRICITY

Trade Knowledge

References

(1) pp 153-154

1. Electron theory
    a. Electron
    b. Proton
    c. Neutron
2. Electron theory of current flow
3. Static charges
    a. Attraction
    b. Repulsion

Trade Practice   Time 6 hours

Job

Use electrical hand tools for soldering and splicing

Safety

Tools, Equipment, Supplies

Wire strippers
Wire cutters
Drills
Wire gages
Measuring tape

Procedure

1. Practice using wire strippers, wire cutters, and wire gage
2. Practice soldering, assembling and disassembling parts of used refrigeration and air conditioning electrical components
3. Practice soldering, wiring, cabling, and splicing, using the pigtail
4. Use mathematics to indicate fractional sizes of wire; solve some problems dealing with simple fractions, and first degree equations

4. Conductors
    a. Good conductors
    b. Semiconductors
    c. Nonconductors
5. Static electricity
    a. Attraction and repulsion of charged bodies
    b. Electrostatic field
6. Measurement
    a. System of measurement
    b. Measurement of quantities
    c. Measurement of temperature
    d. Comparison of system
7. Work, energy, power, efficiency, horsepower: explanation of each

as applied to work, energy, power, horsepower, efficiency

III. ELECTRICAL TERMS AND UNITS

Trade Knowledge

References

(1) pp 153-158
(11) pp 293-312

1. Electrical units
    a. Volt
    b. Amperage
    c. Ohm
    d. Watt
2. Terms associated with electrical components
    a. Resistors
    b. Coils
    c. Capacitors

Trade Practice   Time 3 hours

Job

Identify electrical component according to wiring diagrams and color codes

Safety

Tools, Equipment, Supplies

Resistors
Capacitors
Wiring diagrams
Coils

Procedure

1. Identify electrical components by their characteristics and by the interpretation of color codes as used in resistors and capacitors
2. Identify electrical symbols that are used in wiring diagrams
3. Examine some of the physical components and draw the symbols for each
4. Draw a simple electrical diagram of a domestic refrigerator and identify each electrical component

    d. Transformers
    e. Insulators
    f. Conductors

3. Symbols and diagrams

    a. Types of symbols
    b. Types of diagrams; pictoral, schematic
    c. Types of electrical circuits; series and parallel
    d. Prefixes used for electrical units

        (1) Kilo-
        (2) Milli-
        (3) Micro-
        (4) Micro-micro- (pico)
        (5) Mega-

IV. MAGNETISM

Trade Knowledge

References

(1) p 157
(8) RSA#1 Job #1
RSA#2 Job #2

1. Magnetic poles

    a. Molecular theory
    b. Fundamental laws of magnetism
    c. Factors affecting magnetic force

Trade Practice

Time 9 hours

Job

Determine the polarity of a magnet and construct an electromagnet

Safety

Tools, Equipment, Supplies

Magnet, bar
Filings, iron
Compass
Wire, #22
Contactor, 3-phase; with holding coil
Transformer, step-down;(110-240 volts)

Procedure

1. Determine polarity of magnets with compass
2. Use iron filing to determine the magnetic field
3. Make an electromagnet with a soft iron core

2. Magnetic fields
    a. Magnetic line of force
    b. Introduction to geometric patterns
        (1) Small
        (2) Complex
    c. Properties of magnetic lines of force
    d. Additional characteristics of magnetic fields
3. Types of magnets
    a. Natural magnets
    b. Artificial magnets
    c. Electromagnets
4. Shapes and uses of
    a. Bar magnets
    b. Horseshoe magnets
    c. Ring magnets
5. Electromagnetism
    a. Magnetic field around a conductor
    b. Left-hand rule
    c. Magnetic field around two conductors
    d. Magnetic field around a coil of wire
    e. Solenoid
        (1) Plunger
        (2) Industrial application
    f. Relays
        (1) Overload
        (2) Magnetic-amperage type
        (3) Hot-wire type
        (4) Voltage-magnetic type

4. Increase the number of turns on the core and explain effect on strength of magnetic field
5. Wind an electromagnet with a few loose turns of wire and explain the effect opon the magnetic field
6. Wind an electromagnet with the turns close together and explain the effect upon the magnetic field
7. Connect two coils in series with the magnetic fields aiding each other
8. Connect two coils in series with magnetic fields opposing
9. Examine a 3-phase compressor starting contactor
10. Explain the operation of the holding coil and draw the electrical symbols for a contactor with a 24-V holding coil
11. Write an explanation of the relationship of electromagnet constructed above and the holding coil of the contactor

V. RESISTANCE - OHM'S LAW - CIRCUITS

Trade Knowledge

References

(1) p 155
(8) RSA#5 Job #5, Unit II
(11) pp 293-303

Trade Practice Time 15 hours

Job

Construct and analyze a series circuit, parallel circuit, and series-parallel circuit

Safety

1. Definition of resistance
2. Types of resistors

    a. Wire-wound
    b. Composition
    c. Other

3. Resistance of wire conductors

    a. Copper
    b. Aluminum
    c. Nichrome

4. Effects of the following items on resistance

    a. Size of conductor
    b. Length of conductor
    c. Temperature coefficient

5. Ohm's law

    a. The fundamental relationship that exists between voltage, current, and resistance
    b. Relationships that are associated with Ohm's law

6. Electrical circuits

    a. Series
    b. Parallel
    c. Series-parallel

Tools, Equipment, Supplies

VOM
Ammeter
Resistors
Wire, nichrome
Wire, copper
Aluminum

Procedure

1. Construct a series circuit and measure the resistance of each resistor; compare the measured reading with the color of the code value
2. Measure the total resistance of the circuit and compare with the addition of each individual measurement
3. Apply power to the circuit and measure the voltage drop across each resistor
4. Add each of the individual voltage drops and compare with the total measured input voltage of the circuit
5. Measure the current in the circuit and use Ohm's law to calculate the individual voltage drops
6. Compare the calculated reading with the measured reading
7. Repeat the above step with a parallel circuit and a series-parallel circuit
8. Measure the resistance of the starting and running winding of an electric motor
9. Compare the resistance reading of the electric motor windings and explain the difference in values of resistance

VI. PRINCIPLES, USE, AND CARE OF VOLT, AMPERE, OHM, AND WATT METERS

Trade Knowledge

References

(1) pp 184, 185
(11) p 278, 283
(8) RSA#4 Job #4

Trade Practice Time 15 hours

Job

Make measurements using a volt, ampere, ohm, and watt meter

1. Types of meters used
   - a. VOM
   - b. Ammeter
   - c. Clamp-on-type meter
   - d. Voltmeter
   - e. Ohmmeter
   - f. Voltage tester a-c and d-c
   - g. Wattmeter
2. Purpose of each type of meter
3. Basic operation of meter movement
4. Type of meter movements
   - a. D'Arsonval type
   - b. Iron vane type
   - c. Dynamometer type
   - d. Other
5. Damping of a meter
6. Sensitivity and accuracy of meter movements
7. Reading of meter scales
8. Techniques used in connecting meters in a circuit for correct measurements
9. Shunting of an ammeter

Safety

1. Take necessary precautions to prevent electrical shock
2. Avoid connecting meter into the circuit incorrectly
3. THINK when using a meter

Tools, Equipment, Supplies

VOM
Ammeter, 0-15 amps
Wattmeter
Meter, clamp-on-type
Voltage tester, a-c and d-c
Motor, 1/3-hp
Voltmeter, 0-300 volts

Procedure

1. Connect a 1/3-hp, single-phase motor in a circuit; observe the operation of the motor
2. Unplug the motor and draw a diagram of the starting and main windings of the motor
3. Measure the resistance of each winding and compare the value of each winding
4. Reassemble motor connections and place an ammeter in series with the circuit
5. Place the motor in operation, read and record the amperage of the motor
6. Measure the amperage of the motor with clamp-on-type meter and compare the two ammeter readings with each other
7. Measure the voltage in the circuit
8. Measure the wattage in the circuit
9. Compare the amperage, voltage, and wattage reading with the information on the nameplate
10. Use the VOM to measure the resistance of several sizes of small coils of wire
11. Measure the resistance of several composition and wire wound resistors
12. Use the VOM in making continuity checks

VII. INDUCTANCE

Trade Knowledge

References

(1) p 159
(11) pp 295-296

1. Explanation of inductance and an inductor
2. Purpose and use of inductors
3. Types of inductors
   a. Coils
   b. Chokes
   c. Transformers
4. Unit of inductance
   a. Henry
   b. Microhenry
5. Phase relationship in a circuit containing inductance
6. Self-inductance
7. Mutual inductance
8. Connecting inductors
   a. Series (magnetic field aiding)
   b. Series (magnetic field opposing)
   c. Parallel
9. Explanation of an inductor in a relay
10. Explanation of an inductor in a motor
11. Explanation of function of an inductor in a solenoid

Trade Practice

Time 12 hours

Job

Examine solenoids, relays, and motors for types of inductors used and construct coils and solenoids

Safety

Tools, Equipment, Supplies

Motor, induction; 1/3-hp
Relay, control
Relay, overload
Solenoid
VOM
Wire, #22

Procedure

1. Construct a simple coil in a 1/4" hollow core; connect each end of coil to a power source and move a metal bar in and out of the core; explain the action of the coil
2. Increase the number of turns on the coil and repeat the above steps
3. Construct a coil so that the metal plunger will be drawn into the center of the coil and explain the action
4. Construct a coil so that the metal plunger will be rejected from the coil and explain this action
5. Connect two coils in series with magnetic fields aiding each other
6. Connect two coils in series with magnetic fields opposing each other
7. Examine several coils and write what each coil is used for
8. Disassemble the 1/3-hp induction motor; explain the effect of increasing or decreasing the number of turns in the motor; explain the effect of increasing or decreasing the size of wire used in the motor
9. Examine several relays and explain the operation of each

12. Explanation of back emf
13. Importance and use of inductors in control circuits

10. Examine several solenoids and explain the action of each
11. Draw a schematic symbol of a coil, motor windings, solenoid, overload relay, control relay, and a contactor with a holding coil
12. Use a schematic wiring circuit drawing and identify each of the above components

VIII. CAPACITANCE

Trade Knowledge

References

(1) pp 171, 172
(11) pp 296, 297
(8) Unit II, RSA#11, Job #11

1. Definition of capacitance and capacitive reactance
2. General types of capacitors
    a. Electrolytic (start capacitor)
    b. Paper and oil (running capacitor)
3. Parts of capacitor
    a. Plates
    b. Dielectric (insulating material)

Trade Practice

Time 12 hours

Job

Check and replace capacitors

Safety

Always discharge a capacitor before handling

CAUTION: A starting capacitor is designed to be in the circuit only a short time; therefore, any readings must be taken in a matter of five to eight seconds

Tools, Equipment, Supplies

Motor, capacitor; 1/3-hp
Capacitor checker
Capacitor
VOM
Ammeter, 0-30 amps
Voltmeter, 0-300
Motor, capacitor-run, capacitor-start; 1/4-hp

Procedure

1. Examine a capacitor and record the data marked on the outside of the container (example 250 mfd, 250 VDC); name the parts of the capacitor
2. Use the nameplate data of amperage and voltage to calculate the mfd rating of capacitor

$$\text{mfd} = 2650 \times \frac{\text{amp}}{\text{volts}}$$

3. Compare the calculated value with the value marked on the capacitor

4. Basic factors which influence the capacitance of a capacitor
    a. Area of plates
    b. Distance between plates
    c. Type of dielectric
5. Use of capacitors
    a. To neutralize the effects of inductance
    b. To obtain pulses
    c. To reduce sparking when contact points are involved
    d. Many other uses in a-c circuits
6. Explanation of how current leads the voltage in a capacitive circuit
7. Connecting capacitors in series
8. Connecting capacitors in parallel
9. Physical construction of an electrolytic and oil capacitor
10. Checking a capacitor with VOM for
    a. Shorts
    b. Open
    c. Satisfactory condition
11. Checking a capacitor with a capacitor checker
12. Figuring the approximate value of a capacitor, using the formula

$$\text{mfd} = 2650 \times \frac{\text{amp}}{\text{volts}}$$

13. Effects of a defective capacitor on a capacitor-start motor
14. Effects of a defective running capacitor in a motor circuit

4. Check the capacitor with an ohmmeter for an open, shorted, or satisfactory condition
5. Make a live or positive test, using an ammeter and voltmeter in a circuit for testing capacitors
6. Use the reading of voltage and amperage to calculate the value of capacitor in mfd; use the formula

$$\text{mfd} - 2650 \times \frac{\text{amp}}{\text{volts}}$$

7. Place a 1/3-hp capacitor-start motor in operation. Observe the starting torque and time that it takes the motor to reach full speed
8. Replace the capacitor with a faulty capacitor
9. Place the motor in a live circuit
10. Place a capacitor-start capacitor-run motor in operation with an ammeter in the circuit
11. Break the circuit and replace the running capacitor with a faulty capacitor
12. Energize the circuit for a few seconds only. NOTE: High amperage drawn by the motor.

IX. ALTERNATING CURRENT

Trade Knowledge

References

(1) pp 156-157
(11) pp 309-323

Trade Practice — Time 12 hours

Job

Use oscilloscope to observe a sine wave and explain operation of simple a-c generator

1. Introduction to sine wave
    a. Comparison of alternating current and direct current
    b. Electromagnetic induction
    c. Magnitude and direction of induced emf
2. Operation of simple two-pole generator
3. Operation of two-phase generator
4. Operation of three-phase generator
5. Characteristics of sine wave
    a. Instantaneous peak and peak-to-peak values of voltage
    b. Average value of voltage
    c. Effective or rms value of voltage
    d. Phase difference and phase angle
    e. Frequency and period

Tools, Equipment, Supplies

Transformer, step-down; 110-240 volts
VOM
Load resistor
D-C power source (optional)

Procedure

1. Use oscilloscope to observe a sine wave form from output of the step-down transformer (control transformer)
2. Use oscilloscope to observe the input of the voltage of the transformer
3. Calibrate the oscilloscope for measurement of a-c voltages
4. Measure the 24 volts output of tran transformer, using the oscilloscope
5. Use mathematical formulas to calculate average or rms peak, and peak-to-peak voltages
6. Measure peak-to-peak values, using the oscilloscope
7. Use oscilloscope to observe a d-c wave form
8. Draw a simple two-pole generator
9. Explain the difference between an a-c generator and a d-c generator

X. TRANSFORMERS

Trade Knowledge

References

(4) pp 148-149
(5) pp 302-306
(11) pp 280-281

Trade Practice Time 6 hours

Job

Construct a step-up and step-down transformer

Safety

Tools, Equipment, Supplies

Wire, #22; several feet
Cylinder, round air-core ceramic or paper
Transformer, step-down; 110-240 v, a-c
VOM
Load resistor

1. Types of transformers
    a. Power
    b. Instrument
    c. Auto
    d. Step-up
    e. Step-down
    f. Other
2. Purpose and use of transformers
3. Construction of transformers
4. Effects of eddy currents
5. Explanation of how the voltage and current in the secondary are a function of the primary
6. Use of VOM to check continuity and resistance of a transformer
7. Identification of leads of transformer
8. Use of 24-volt control transformers in air-conditioning and refrigeration control circuits

Procedure

1. Construct a simple transformer
2. Vary the number of turns in the primary and secondary
3. Show that the voltage and current in the secondary are a function of the primary
4. Use the VOM to make voltage, current, and resistance measurements of a transformer
5. Connect a step-down, 110 to 24-volt control circuit transformer in a circuit with a small load resistor
6. Measure the input voltage and output voltage
7. Measure the input amperage and output amperage
8. Use mathematical formulas to figure the number of turns in the primary and secondary
9. Draw a simple control circuit, using 24-volt control transformer
10. Practice reading a schematic wiring diagram

XI. RELAYS

Trade Knowledge

References

(1) pp 142, 149
(8) RSA#7 Job #7

Trade Practice Time 6 hours

Job

Check or replace relay

Safety

If relay is to be removed from the circuit, a check should be made for a live circuit

Tools, Equipment, Supplies

1	Refrigeration unit with current magnetic relay
1	VOM
1	Meter, clamp-on-type
1	Refrigeration unit with voltage magnetic relay
1	Refrigeration unit with hot-wire relay

1. Types of relays
    a. Magnetic amperage type
    b. Hot-wire type
    c. Voltage magnetic type
2. Purpose and operation of each type
    a. Magnetic amperage type is used in starting winding circuit of motor and used the electrical characteristics of the motor to operate it
    b. Hot-wire relay is used in the starting winding and works on the theory that electrical energy can be turned into heat energy
    c. Magnetic voltage relay is also in the starting circuit and is based on the principle of an increase in voltage as unit reaches a certain speed
3. Use of drawings, specifications, manufacturers' catalogs, service manuals, nameplate data and handbooks to determine characteristics
    a. Type of relay
    b. Voltage rating
    c. Amperage rating
    d. Connections
    e. Numbering data according to manufacturer
4. Interpretation of National Association of Relay Manufacturers (NARM) nomenclature
5. Importance of correct location of controls
6. Effect of ambient temperature
7. Methods of installing control devices
    a. Panels
    b. Enclosures
    c. Boxes
8. Methods of wiring and connecting
9. Methods of testing for
    a. Continuity
    b. Grounds and shorts

Procedure

1. Obtain a refrigeration unit with a relay control in compressor starting circuit
2. Use a set of manufacturers' drawings or wiring diagrams to locate and determine the type and connections of a relay
3. Locate the relay in the electrical circuit and make the following checks
    a. For continuity
    b. For normally open or normally closed
    c. For the contacts for pits
4. Place the unit in operation and make a voltage or current check on the relay. NOTE: A starting relay should remain energized in a live circuit for only a few seconds to prevent damage to the motor
5. Disconnect the unit and remove the relay
6. Replace the relay with a substitute relay
7. Use manufacturers' catalogs, manuals and handbooks to obtain the
    a. Type
    b. Voltage
    c. Amperage
    d. Connections
    e. Mounting position
8. Check all work for completeness and place the unit in operation

    - c. Mechanical tightness
    - d. Polarity

10. Inspection and checking of air gaps
11. Techniques of inspecting and checking mechanical components and linkage
12. Importance of care and cleanliness
13. Substitution of relays
    - a. The necessity of knowing exact electrical characteristics
    - b. The relay mounted in the proper position
    - c. The proper type of relay
14. Defective or burned out relays
    - a. Incorrect relay: check and replace
    - b. Incorrect mounting angle: remount relay in correct position
    - c. Line voltage too high or too low: determine the reason and correct it
    - d. Relay being influenced by loose mounting vibration: remount rigidly

XII. HAND TOOLS

Trade Knowledge

References

(1) pp 54-64

Trade Practice Time 12 hours

Job

Use hand tools for various jobs

Safety

1. Do not use hammers that have heads loose on the handle
2. Do not use screwdrivers for chisels and pry bars
3. Do not use chisels that have become mushroomed on the driving end
4. Use proper size wrench for the nut to be removed or tightened
5. Never use file without handle on tang

1. Torsioning tools
    a. Screwdriver
    b. Wrenches
2. Screwdrivers
    a. Common (flat blade)
    b. Reed
    c. Prince
    d. Phillips
3. Use, purpose, and description of each type
4. Socket wrenches and attachments
    a. Types, sizes, and uses of sockets
    b. Types, sizes, and use of ratchets

Tools, Equipment, Supplies

Screwdrivers, flat blade; assorted sizes
Screwdrivers, Phillips #1, #2
Screwdrivers, offset
Wrenches, socket; with attachments
Wrenches, box end
Wrench, crescent
Wrench, pipe
Wrench, Allen
Wrench, torque
Hammer, ball peen
Hammer, claw
Hammer, plastic
Mallet, rawhide
Pliers, diagonal cutting
Pliers, long-nose
Shears, tinners
Square, combination set
Chisels
Scribe
Files: coarse, bastard, second-cut, smooth
Hacksaw
Taps and dies (small set)
Calipers
Scales
Tubing cutter
Bending spring
Gage, screw pitch
Gage, thickness
Block, pinch-off
Bender, tube
Tool, flaring

Procedure

1. Identify each of the tools in the student tool kit and on all the tools listed in the above tool list
2. Use the hand tools listed above in a simple work project to illustrate the knowledge and proper use of each

  - c. Extension bars
  - d. Universal joints for inaccessible places

5. Box end wrenches
   - a. Types, sizes, and uses
   - b. Offset of wrench shank

6. Adjustable wrenches
   - a. Types, sizes, and use of each type
   - b. Techniques in using adjustable wrenches

7. Torque indicating wrench
   - a. Types of torque wrenches
   - b. Reading or torque indicator

8. Hammers
   - a. Types, sizes, and use of each type
     - (1) Claw
     - (2) Ball peen
     - (3) Plastic
   - b. Techniques in gripping and striking an object with a hammer

9. Pliers
   - a. Types, sizes, and uses of pliers
     - (1) Diagonal-cutting
     - (2) Long-nose
     - (3) Combination slip-joint
     - (4) Other
   - b. Techniques in gripping an object with pliers

10. Shears
    - a. Types, sizes, and uses of each
    - b. Selection of hacksaw blades according to the number of teeth and material to be cut

11. Squares
    - a. Types, sizes, and uses of each
      - (1) Combination
      - (2) Carpenter's

    b. Making linear and angular measurements with square

12. Hacksaws

    a. Types, sizes, and uses of each
    b. Selection of hacksaw blades according to the number of teeth and material to be cut

13. Files

    a. Types of files

        (1) Coarse
        (2) Bastard
        (3) Second-cut
        (4) Smooth
        (5) Dead-smooth

    b. Sizes and uses of files

        (1) Use dependent on type of material to be filed
        (2) Smoothness of surface dependent of type and size of file used

14. Taps and dies

    a. Types of taps

        (1) Tapered taps
        (2) Plug tap
        (3) Bottoming tap

    b. Purpose and use of each type of tap
    c. Techniques in cutting threads with a tap

15. Gages

    a. Types

        (1) Thickness gage
        (2) Screw pitch gage

    b. Techniques used in measuring with gages

16. Tubing cutter

    a. Use of a tubing cutter
    b. Techniques in cutting tubing with a tubing cutter

17. Flaring tool
    - a. Type of flaring tools
        - (1) Single flare
        - (2) Double flare
    - b. Use of flaring tools
    - c. Techniques in making a flare with a flaring tool

18. Pinch-off block
    - a. Use of pinch-off block
    - b. Methods of installing and removing a pinch-off block from tubing

19. Cleaning and care of wrenches
    - a. Washing grease and solvent from wrenches with cleaning solvent
    - b. Removing rust from wrenches with crocus or abrasive cloth
    - c. Applying a thin coat of oil on tools to prevent rust

XIII. REFRIGERATION FITTINGS

Trade Knowledge

References

(1) pp 32, 35, 37, 46, 63, 125, 483, 504
(7) RSA#3 Job #3

1. Type of fittings
    - a. Capillary-tube
    - b. Commercial
    - c. Flared
    - d. Refacers
    - e. Streamlined
    - f. Tubing

Trade Practice Time 3 hours

Job

Identifying refrigeration fittings

Safety

Tools, Equipment, Supplies

Fittings, copper, brass, etc.; assorted
Wrenches, ratchet; 1/4" to 3/4"
Vise
Flaring kit

Procedure

1. Select a number of fittings of different sizes and types
2. Identify each type of fitting
3. Make a run of tubing, using a union, male elbow, female elbow, male tee, and female tee

2. Purpose of each type of fitting
3. Type of threads used on most fittings
    - a. Standard
    - b. SAE (National fine)
4. Type of material from which fittings are made
    - a. Copper
    - b. Aluminum
    - c. Brass
    - d. Steel
    - e. Plastic
5. Flare tube fittings
    - a. Male elbow
    - b. Female elbow
    - c. Reducing union elbow
    - d. Female swivel elbow
    - e. Short nut
    - f. Long nut
    - g. Plug
    - h. Male branch tee
    - i. Union tee
    - j. Male run tee
    - k. Reducing union tee
    - l. Manifold union coupling
    - m. Swivel flare nut to solder adapter
    - n. Flare to solder union
6. Fusible metal pipe plugs
7. Capillary-tube fittings
8. Cylinder-adapter fittings
9. Compression-tube fittings
    - a. Sleeve
    - b. Nut
    - c. Union
    - d. Ball check
    - e. Elbow check
    - f. Union tee
    - g. Restricted flow connector
    - h. Tank fitting
10. Universal fittings for making connections with either plastic or soft metal fitting
    - a. Bodies and nuts are made of brass
    - b. Nut is half-knurl, half-hex for finger tightening to plastic tubing

11. Protection of fittings
    - a. To prevent damage of threads
    - b. To prevent damage to 45° flare
12. Fitting sizes as related to tubing sizes
13. Thread lubricants and sealers, as applicable to the types of fittings

XIV. PIPE CUTTING AND THREADING

Trade Knowledge

References

(1) pp 61-64
(9) RSA#5 Job #8
(11) p 158

1. Types of piping
    - a. Galvanized
    - b. Lead
    - c. Plastic
    - d. Copper
    - e. Aluminum
    - f. Other
2. Type, size, and use of stocks, dies, and cutters

Trade Practice

Time 15 hours

Job

Make a short run of pipe, using 1/2" and 3/4" pipe with assorted couplings

Safety

Tools, Equipment, Supplies

Cutter, pipe
Reamer, burr
Oil can
Vise, pipe
Wrench, pipe; 12"
Wrench, pipe; 14"
Flare, half union; 1/4" x 1/4"
Pipe, 1/2" x 2' long
Pipe, 3/4" x 8" long
Elbow, 1/2" x 3/4"
Pipe union, 1/2"
Cutting oil
Reamer, pipe
Sealer compound

Procedure

1. Clamp 1/2" pipe, 2' in length in a pipe vise
2. Cut three pieces of 1/2" pipe 8" long
3. Clamp the piece of pipe to be threaded in the pipe vise and ream each end of the pipe
4. Select the die size for the pipe to be threaded and fit the die in stock
5. Fit die on pipe, with guide toward vise and start die to cutting thread

3. Techniques used to start the thread correctly
4. Cutting the thread
    a. Turn 1/4 to 1/2 turn clockwise then 1/4 to 1/2 turn in a counterclockwise direction
    b. Use cutting fluids
5. Type of cutting fluids used to cut threads
6. Proper length to thread standard piping
7. Thread types
    a. NF
    b. NC
    c. V threads
8. Connecting piping with fittings
    a. Union
    b. Tee
    c. Elbows
    d. Other
9. Importance of closely fitting joints to prevent leaks

6. Turn die clockwise and oil dies with cutting oil every few turns
7. Cut threads to a length of about 3/4 the diameter of the OD of the pipe
8. Reverse stock ratchet and turn counterclockwise to remove stock and die from pipe
9. Thread both ends of each piece of pipe
10. Connect the pipes together in one run, using 1/2" pipe tee, 1/2" plug, 1/4" flare x 1/4" male pipe union, 1/2" x 3/4" elbow, 3/4" pipe cap, 1/2" pipe elbow and 1/2" pipe union
11. Tighten all joints, using pipe wrenches
12. If available, plug one end of pipe run and test with about 30 pounds of air pressure

XV. SOFT-SOLDERING JOINTS

Trade Knowledge

References

(1) p 37
(7) RSA#5 Job #4, #5
(11) pp 243, 250

Trade Practice Time 12 hours

Job

Soft-solder joints of tubing

Safety

Always keep torch pointed away from the body

Tools, Equipment, Supplies

Torch
Brush, wire; small
Solder, 60/40
Couplings, 1/4", 3/8", 1/2", 5/16", 3/4"
Adapters, 1/4" x 1/2", 1/2" x 3/4"
Tees, 1/4", 3/8", 1/2", 3/4"
Steel wool
Sandpaper
Vise
Hacksaw
Cutter, tubing
Tubing, 1/4", 3/8", 1/2", 3/4"

1. Sizes of tubing
2. Size and type of fittings
    a. Coupling
    b. Adapters
    c. Tee
3. Cutting of tubing with
    a. Hacksaw
    b. Tubing cutter
4. Importance of deburring tubing and removing filing from inside tubing
5. Cleaning of tubing with
    a. Sandpaper
    b. Sand cloth
    c. Steel wool
6. Use of noncorrosive flux
7. Techniques of joining fitting and tubing for proper fits
8. Techniques used in heating solder joints to insure a uniform solder joint
9. Types of solder to be used in making solder joint
    a. 50/50 tin and lead
    b. 95/5 tin and lead
10. Purpose in using different types of solder
    a. Melting points
    b. Solder joints that are made for use in low-temperature units
11. Importance of appearance, neatness and condition of solder joints

Procedure

1. Select a piece of 1/2" copper tubing and a T
2. Place tubing in a vise and take the necessary precautions to prevent crimping the tubing
3. Cut tubing to the proper length and remove burrs with file or scraper
4. Clean outside of tube with sandpaper or a sand cloth
5. Apply fluid thoroughly to inside of fitting
6. Apply fluid to outside of tube; assemble tube and fitting
7. Insert tube into fitting so as to have a snug fit
8. Apply heat uniformly around fitting
9. When solder melts upon contact with the fitting, remove the flame
10. Feed solder at one or two points on the joint; when collar is formed around the fitting, stop feeding solder
11. Wipe off excess solder with a wet rag or a small brush
12. Let solder joint cool and inspect for excess solder, appearance, condition, etc.

XVI. FABRICATION OF TUBING

Trade Knowledge

References

(1) pp 31-42
(7) RSA#2 Job #2, #4, #5

Trade Practice

Time 12 hours

Job

Fabricate tubing

Safety

1. Unrolling of tubing from master roll
    a. Effects of improper unrolling
    b. Effects of improper bending of tubing
2. Use of tubing cutter
    a. Types of cutters
    b. Care of tubing cutters
3. Use of hacksaw
    a. Types of blades to be used in cutting tubing
    b. Techniques used in cutting with a hacksaw
4. Use of inside caliper to measure the diameter of tubing
5. Use of micrometer to measure the OD of tubing
6. Transferring of measurements from calipers to micrometers
7. Care of measuring instruments
    a. Micrometer
    b. Calipers
8. Use of flare blocks and vises for holding tubing
9. Effects of excessive pressure on tubing when clamping the tubing in a vise
10. Results of improper flaring
    a. Flare too thin because of too much pressure applied to the cone
    b. Split flare caused by the improper seating of tubing in the flaring tool

Tools, Equipment, Supplies

Tubing, 1/4", 3/8", 1/2", 3/4"
Bender, tubing; for 3/8", 1/4", 1/2", 3/4"
Hacksaw
Cutter, tubing
Micrometer
Tool, flaring
File
Vise

Procedure

1. Unroll tubing from larger roll and cut off a piece 12" in length with a tubing cutter or hacksaw
2. Ream and file the edge of tubing for deburring
3. Measure the outside (OD) of the tubing with a micrometer
4. Place the tubing in a flare block and clamp tubing firmly; the tubing should extend about 3/16" above the block
5. Select the proper yoke for the size of tubing to be flared and attach it to the flare block
6. Place a drop of oil on the cone
7. Screw the cone firmly into the end of the tubing to make a 45° flare
8. Unscrew cone and remove tubing from the flare block
9. Examine the flare for defects such as: flare too thin, split flare, uneven flare
10. Join the flare and a fitting and observe the closeness of fit
11. Place the tubing in a tube-bending tool and make a 45° bend, a 90° bend, and a 180° bend
12. Observe the tubing for the following defects
    a. Collapsed
    b. Stretched
    c. Hard as a result of working
13. Repeat the above steps, 1 through 14, several times with different sizes of tubing

   c. Uneven flare caused by the improper seating of tubing in the flaring tool

11. Importance of the closeness of fit that the flare tubing makes with the fitting
12. Methods of bending tubing

    a. Bending tool
    b. Hand

13. Use of bending machines and springs
14. Bending allowances for different sizes of tubing and types of bends to be made
15. Metal stresses

    a. Hardening
    b. Stretching

16. Results of improper bending

XVII. WELD SHEET METAL WITH OXYACETYLENE

Trade Knowledge

References

(1) pp 298-300

1. Purpose and use of the basic equipment
    a. Gas supply: oxygen and acetylene
    b. Gas regulators

Trade Principles Time 6 hours

Job

Butt-weld two pieces of mild sheet steel

Safety

Wear properly fitting protective clothing and welding goggles with #5 shade lens

Tools, Equipment, Supplies

Oxyacetylene welding outfit, complete
Welder's tools, 1 set
Welding tip
Mild steel sheet, 16-gage x 4" x 6"; (2 pieces)
Filler rod

Procedure

1. Set up and adjust the oxyacetylene welding equipment
2. Clean the edges of the pieces to be welded

   - c. Hose
   - d. Torch and tips

2. The oxyacetylene flame
   - a. Parts
   - b. Temperature
   - c. Colors

3. Technique of good welding
   - a. Selection of tip
   - b. Adjustment of torch
   - c. Angle of torch
   - d. Form of the puddle
   - e. Movement of the filler rod and the torch

4. Appearance of a good weld
   - a. Beads even in width
   - b. Fine, regularly spaced ripples
   - c. Slight convex above joint
   - d. No undercutting
   - e. Good, even penetration

3. Place the two pieces with a long edge of each in a parallel position at a distance of 1/16" (called a gap)
4. Attach the welding tip, light the torch, and adjust a neutral flame
5. Make 1/4" tack welds at either end and at 1 1/2" intervals in between
6. Begin weld at the right-hand end of the joint; carefully observe the puddle; add filler rod as necessary, and move at the optimum speed
7. When the weld is completed, cut off the torch and cool the piece of work
8. Make a visual examination and a bend test

XVIII. WELD PIPE WITH OXYACETYLENE

Trade Knowledge

References

(1) pp 298-300

1. Variations in angles of the torch when welding pipe
2. Use of the filler rod to control the puddle
3. Method for beveling the pipe edge

Trade Principles Time 6 hours

Job

Butt-weld short sections of pipe in the horizontal and the vertical positions

Safety

Tools, Equipment, Supplies

Complete oxyacetylene welding outfit
Welder's tools, 1 set
Welding tip
Pipe, short lengths: 1" diameter
Filler rod, mild steel

Procedure

1. Set up the oxyacetylene welding equipment
2. Select two pieces of 1" diameter pipe; align on a jig with the weld in a vertical position; leave a 1/32" gap

4. Proper space between pieces of pipe
5. Reasons for poor welds
    a. Puddle varied in size
    b. Irregular speed along the joint
    c. Filler rod added improperly
    d. Torch improperly adjusted and/or held
6. Positions clocked as they refer to the points on a circle
7. Purpose of and method of tacking pipe

3. After attaching the welding tip, light the torch and adjust a neutral flame
4. Tack-weld at four evenly spaced places; remove the jig
5. Begin welding at the 2 o'clock position and weld up to 12 o'clock; use a high torch angle and observe closely for penetration
6. Rotate the pipe so that the end of the weld is in the 2 o'clock position
7. Resume welding at 2 o'clock and weld to 12 o'clock
8. Continue the method of rotation and welding
9. Cut off the torch and cool the joint
10. Make a visual examination and a destructive test of the joint
11. Repeat the above steps with the weld in horizontal position

XVIX. CUTTING WITH OXYACETYLENE

Trade Knowledge

References

1. An explanation of "burning"
2. Types of cutting tips
    a. Thin-plate
    b. Rivet-splitting

Trade Principles Time 3 hours

Job

Use an oxyacetylene cutting torch to cut sheet metal and pipe

Safety

Remove all combustible material from the area where the cutting is to be done

Tools, Equipment, Supplies

Oxyacetylene cutting outfit, complete
Welder's tools, 1 set
Sheet steel, 16-gage; scrap (several pieces)
Mild steel plate, 3/8"; scrap (several pieces)

Procedure

1. Set up the equipment and adjust the gas pressures
2. Place a piece of scrap so that one edge hangs over the edge of the work table

c. Gouging
d. Other

3. Technique of cutting

   a. Torch angle
   b. Preheating
   c. Feeding oxygen
   d. Speed of movement

3. Light and adjust the cutting torch for light cutting (16-gage)
4. Use the left-hand to support the torch, and as a pivot point on short or curved cuts
5. Direct the flame at the point where cutting is to begin; hold the torch head about 5° off the vertical position and away from the direction of travel
6. Allow the metal to preheat until a puddle begins to form
7. Press the oxygen, or cutting, lever slowly
8. As the flame penetrates, move it slowly at a regular rate in the desired direction of travel
9. Cut off the torch; cool the piece and examine the cut
10. Repeat the above steps for pieces of 3/8" plate

XX. SERVICE ENTRANCE, 1-PHASE, 3-WIRE

Trade Knowledge

References

(14) pp 2-24, 9-220

Trade Practice Time 12 hours

Job

Install a single-phase service entrance (3-wire)

Safety

Take necessary precautions to prevent electrical shock--ground all power tools when they are being used

Tools, Equipment, Supplies

Meter base, socket-type; 1" hub
Weatherhead for 3-wire service entrance
Conduit, 1"; 9' long
Connector, entrance cable; 3-wire, #6 (10 feet)
Wire, #8 (8 feet)
Electrode, grounding
Clamp, ground
Pliers, side cutting
Drill, electric; 1/2"
Saw, keyhole
Screwdriver, 6"
Screwdriver, 4"
Hammer, claw
Rule, 6'

1. General description of service entrance
2. Types of service entrance
    a. 3-phase, 4-wire
    b. 1-phase, 3-wire
    c. 1-phase, 2-wire
3. Purpose and application of each
4. Type of feeder system (example 480 volt, 208Y/120)
5. Location of service entrance
6. Type of conductors used
    a. #6 wire, current-carrying capacity
    b. #8 wire, current-carrying capacity
7. Type of weatherhead
    a. 3-wire
    b. 4-wire
    c. 2-wire
8. Matching conductors to load
9. Type of meter base
    a. 110 volt, 2-wire
    b. 220 volt, 3-wire, socket type
10. Use of drawings, specifications, manufacturers' catalogs, handbooks, and service manuals to determine the
    a. Type
    b. Size
    c. Voltage
    d. Amperage ratings
    e. Connections of panel board and meter
11. Use of National Electrical Code and local codes relevant to service-entrance installation
12. Ground procedure

Panel, twelve-circuit-breaker; surface mounting
Mounting bolts and screws for mounting service-entrance conduit
Conduit, 3/4" (10 feet)
Circuit breakers, single-pole, 15-amp (4)

Procedure

1. Draw a diagram of service-entrance circuit, including panel-board bus bars and connection of branch circuits to bus bars
2. Consult a set of drawing specifications, manufacturers' catalogs, handbooks, and service manuals to determine ratings of conductors, meters, and special hardware information
3. Consult the national electric and local code relevant to installation of service entrance
4. Mount meter base
5. Run conduit from weatherhead to meter base
6. Run #6 entrance cable in 1" conduit and install weatherhead
7. Mount circuit-breaker panel
8. Run conduit from meter base to circuit-breaker panel
9. Pull #8 (3-wire) cable from meter base through conduit to circuit-breaker panel
10. Connect #8 wires to meter base and main lugs of panel
11. Install watt-hour meter in meter base
12. Install circuit breakers in panel board
13. Check all work for completeness
14. Connect to a 120/240 power source

13. Special hardware
    a. Weatherhead
    b. Water-tight connections
    c. Ground rod
    d. Conduit connectors

XXI. CIRCUIT BREAKERS

Trade Knowledge

References

(14) pp 9-29 to 9-59, 4-73 to 4-130

1. Use of electrical drawings
2. Rating and characteristics of circuit breakers
    a. Interrupting current rating
    b. Thermal

Trade Practice

Time 24 hours

Job

Install circuit breakers

Safety

Take the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

Lighting panel, 12-circuit, 100-amp rating
Power panel, with 100-amp rating
Circuit breakers, 15-amp, single-pole, (4)
Circuit breakers, 30-amp, 3-pole, 220v single-phase (2)
Circuit breakers, 30-amp, 2-pole, 230v, single-phase (2)
Circuit breakers, 30-amp, 3-pole, 230v 3-phase (2)
Starters, magnetic; with thermal overload protection #0 (2)
Bender, conduit; for 3/4" EMT
Fittings, conduit
Control, pushbutton; start-stop
VOM
Ammeter, clamp-on-type
Cutters, lineman's; 9" (1 pair)
Pliers, diagonal; 6"
Pliers, long-nose; 6"
Pipe threading set
Screwdrivers, assorted sizes
Wire, #14, #12, #10, and #8 TW

Procedure

1. Draw or obtain print layout of circuit to be constructed
2. Obtain panel and breakers
3. Mount panel board on stand
4. Draw panel layout of how circuit breakers are to be installed

   c. Thermal magnetic
   d. Magnetic
   e. Solenoid, circuit breakers

3. Construction features and component parts of circuit breakers
4. Use of National Electrical Code and local codes relevant to installations of electrical wiring and installations
5. Installing circuit breakers in panel board so as to balance the load
6. Types and purposes of conduit
7. Conduit sizes
8. Conduit fittings
9. Number and size of conductions that are permitted in the different sizes of conduit

5. Mount circuit breakers in the panel board
6. Wire complete layout

XXII. REPULSION TYPE - INDUCTION START MOTOR

Trade Knowledge

References

1. Theory of repulsion induction type motor
2. Proper function of brushes
3. Techniques of installing, removing, and lubricating bearings
4. Correct amount of inplay

Trade Practice   Time 12 hours

Job

Test an induction start motor

Safety

Take necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

Sand cloth
Growler
Brushes, new; if applicable (1 set)
Hammer, wooden mallet
Screwdriver
VOM
Rags
Wrenches, assorted
Motor, induction start, induction run

Procedure

1. Remove motor for accessibility
2. Check brushes
3. Check bearings
4. Check inplay
5. Check position of reversing switch
6. Check centrifugal throwout switch

5. Reversing the rotation of an induction motor
6. Operation and mechanical construction of centrifugal switch
7. Use of VOM in checking for starts, open, etc.
8. Use of growler in checking armatures
9. Techniques used in checking motor using a VOM and wiring diagram

7. Check push rods for centrifugal throwout switch
8. Check short circuiting necklace
9. Check armature
10. Check brush bracket
11. Make continuity checks on all motor windings

XXIII. A-C MOTORS: SPLIT-PHASE TYPE

Trade Knowledge

__References__

(8) RSA#9 Job #9A
(13) p 38
(14) pp 7-77, 7-11

1. General description
2. Types
    a. Single-speed
    b. Multiple-speed
3. Purpose and application
4. Use of drawings, specifications, manufacturers' catalogs, and handbooks to determine
    a. Type and size
    b. Voltage and amperage rating
    c. Speed
    d. Nameplate data

Trade Practice

Time __12__ hours

__Job__

Service and make minor repairs on split-phase motor

__Safety__

Take necessary precautions to prevent electrical shock

__Tools, Equipment, Supplies__

Motor, split-phase; 1/4-hp
VOM
Ammeter, clamp-on-type
Tachometer
Identification tags
Wattmeter
Wrenches, nut driver (1 set)
Screwdriver, flat blade; 6"
Pliers, combination
Hammer, soft head

__Procedure__

1. Draw a schematic diagram for a split phase induction motor
2. Explain the operation of this motor
3. Identify the principal parts and explain the function of each
4. Use drawings, specifications, manufacturers' catalogs, and handbooks to determine the characteristics of a split-phase motor
    a. Type and size
    b. Voltage and amperage rating
    c. Speed
    d. Connections
    e. NEMA rating

5. Parts and function of each part
    a. Rotor
    b. Stator
    c. End plates
    d. Centrifugal switch
6. Operation of split-phase motor
    a. Rotor winding
    b. Stator winding

7
        (1) Main winding
        (2) Starting winding
7. Special split-phase motor
    a. Two running windings with one starting winding
    b. Two running windings with two starting windings
8. Rewinding procedure for the split-phase motor
    a. Recording data
    b. Stripping old windings
    c. Insulating the slots
    d. Rewinding
    e. Connecting the windings
    f. Testing
    g. Varnishing and baking
9. Analysis of motor troubles
    a. Mechanical test
        (1) Excessive wear: shaft, bearing, other
        (2) Freedom of rotation: shaft, bearing
        (3) Centrifugal switch
    b. Electrical test
        (1) Ground
        (2) Open winding
        (3) Short
10. Repairs: mechanical, electrical
    a. Worn or tight bearing
    b. Overload devices
    c. Centrifugal switch
11. Reversing a split-phase motor
    a. Interchange of running-winding leads
    b. Interchange of starting-winding leads

5. Compare data from catalogs and handbooks with data on the nameplate
6. Disassemble, remove centrifugal switch, and inspect each part
7. Test stator and windings
8. Identify the leads
9. Reassemble the motor
10. Check shaft rotation manually
11. Connect to proper power source and operate
12. Measure and record voltage, amperage, and wattage
13. Calculate the wattage
14. Measure and record rpm
15. Reverse rotation of motor

XXIV. A-C MOTORS: CAPACITOR TYPE

Trade Knowledge

References

(8) RSA#9 Job #9A
(13) chapter 2

1. General description
2. Types
   a. Capacitor-start, induction-run
   b. Capacitor-start, capacitor-run
3. Purpose and application
4. Use of drawings, specifications, manufacturers' catalogs, and handbooks to determine
   a. Type and size
   b. Voltage rating
   c. Amperage rating
   d. Speed
   e. Connections
   f. Nameplate data
5. Parts and function of each part
   a. Rotor
   b. Stator
   c. End plates
   d. Centrifugal switch or relay

Trade Practice

Time 12 hours

Job

Service and/or make minor repair on capacitor-start motor

Safety

CAUTION: A capacitor is designed to be in the circuit a short time; therefore, reading must be taken in a matter of five to eight seconds

Tools, Equipment, Supplies

Motor, capacitor-start; 1/4-hp
VOM
Ammeter, clamp-on-type
Tachometer
Wattmeter
Nut driver set
Screwdriver, 6"
Hammer, soft head
Pliers, combination
Checker, capacitor
Capacitor, defective
Tags, identification

Procedure

1. Draw a schematic diagram for a capacitor-start motor
2. Explain the operation of a capacitor-start motor
3. Identify the principal parts and explain the function of each
4. Use drawings, specifications, manufacturers' catalogs, and handbooks to determine the following characteristics of a capacitor motor
   a. Type and size
   b. Voltage rating
   c. Amperage rating
   d. Speed
   e. Connections of motor
   f. Nameplate data
5. Disassemble the motor
6. Remove the centrifugal switch and inspect each part of motor and switch

6. Operation of capacitor motor
    a. Rotor winding
    b. Stator winding
        (1) Main
        (2) Starting
    c. Capacitor
7. Analysis of motor troubles
    a. Mechanical tests for
        (1) Excessive wear: shaft, bearing, other
        (2) Freedom of rotation: shaft, bearing
        (3) Centrifugal switch
    b. Electrical tests for
        (1) Ground
        (2) Open winding
        (3) Short
        (4) Defective capacitor
8. Reversing a capacitor motor
    a. Interchange of running-winding leads
    b. Interchange of starting-winding leads
9. Repairs: mechanical, electrical
    a. Worn or tight bearings
    b. Overload devices
    c. Centrifugal switch
    d. Defective capacitor

7. Test stator windings and identify leads
8. Test capacitor for capacitance value and calculate capacitance mathematically
9. Reassemble the motor
10. Check shaft rotation manually
11. Connect to proper power source and operate
12. Measure voltage, amperage, and wattage

XXV. PSC MOTOR

Trade Knowledge

References

(3) p 98-99

Trade Practice Time 6 hours

Job

Troubleshoot PSC motor

Safety

1. Take necessary precautions to prevent electrical shock
2. Always discharge a capacitor before testing or handling the capacitor

Tools, Equipment, Supplies

Refrigeration unit with PSC motor
VOM
Capacitor, defective

XXVI. A-C MOTORS: POLYPHASE TYPE

Trade Knowledge

References

(8) RSA#9, #12, Job #9B, 11, 12

1. General description
2. Types
   a. Three-phase
   b. Two-phase
3. Purpose and application
4. Use of drawings, specifications, manufacturers' catalogs, and handbooks to determine
   a. Type
   b. Size
   c. Voltage rating
   d. Amperage rating
   e. Speed
   f. Connections
   g. NEMA rating
5. Parts and function of each
   a. Rotor
   b. Stator
   c. End plates

Trade Practice

Time 12 hours

Job

Service and make minor repairs on a three-phase motor

Safety

Tools, Equipment, Supplies

Motor, three-phase; 1/3-hp
VOM
Ammeter, clamp-on-type
Tachometer
Tags, identification
Wattmeter
Nut driver set
Screwdriver, 6"
Pliers, combination
Hammer, soft head

Procedure

1. Draw a schematic diagram of a 3-phase motor
2. Explain operations of the motor
3. Identify principal parts and explain function of each
4. Use drawings, specifications, manufacturers' catalogs, and handbooks to determine the following characteristics of a polyphase motor
   a. Type and size
   b. Voltage and amperage rating
   c. Speed
   d. Connections
   e. NEMA rating
5. Disassemble and inspect each part
6. Test the stator winding and identify the leads
7. Reassemble the motor
8. Check shaft manually for free rotation
9. Connect to proper power source and operate

6. Operation of a 3-phase motor
    a. Rotor windings
    b. Stator windings
7. Analysis of motor troubles
    a. Mechanical
        (1) Excess wear: shaft, bearing, other
        (2) Freedom of rotation; shaft, bearing
    b. Electrical
        (1) Ground
        (2) Open winding
        (3) Short
8. Reversing a 3-phase motor (interchanging winding leads)
9. Repairs: mechanical, electrical
    a. Worn or tight bearings
    b. Open phase
    c. Loose rotor bars
    d. Wrong internal connections
    e. Reversed phase
    f. Defective controller

10. Measure amperage, voltage, and wattage
11. Reverse rotation of the motor

XXVII. A-C MOTORS: DUAL-VOLTAGE TYPE

Trade Knowledge

References

(8) RSA#12 Job 12
(13) chapter 2

Trade Practice Time 12 hours

Job

Service and/or make minor repairs on dual-voltage type a-c motor

Safety

Tools, Equipment, Supplies

Motor, dual-voltage capacitor; 1/2-hp
Ammeter, clamp-on-type
VOM
Tachometer
Tags, identification
Wattmeter
Capacitor, defective
Pliers, combination
Nut driver set
Screwdriver, 6"

1. General description
2. Types
    a. Single-voltage
    b. Dual-voltage
3. Purpose and application
4. Use of drawings, specifications, manufacturers' catalogs, and handbooks to determine the characteristics of dual-capacitor motors
    a. Type and size
    b. Voltage and amperage
    c. Speed
    d. Connections
    e. NEMA rating
5. Parts and function of each
    a. Rotor
    b. Stator
    c. End plates
    d. Capacitor
    e. Centrifugal switch or relay
6. Operation of capacitor motor, dual voltage
    a. Rotor windings
    b. Stator windings
        (1) Main
        (2) Starting
    c. Capacitor
7. Analysis of motor troubles
    a. Mechanical
        (1) Excessive Wear: shaft, bearing, other
        (2) Freedom of rotation: shaft, bearing
        (3) Centrifugal switch
    b. Electrical
        (1) Ground
        (2) Open winding
        (3) Short
        (4) Defective capacitor
8. Identifying and labeling
    a. Value of capacitor
    b. Dual-winding leads

Procedure

1. Draw a schematic diagram for a dual-voltage capacitor-start motor
2. Explain the operation of dual-voltage capacitor motor and compare to operation of a single-voltage capacitor motor
3. Identify the principal parts and explain the function of each
4. Use drawings, specifications, manufacturers' catalogs, and handbooks to determine the following characteristics of the dual-voltage capacitor motor
    a. Type and size
    b. Voltage and amperage rating
    c. Speed
    d. Connections
    e. NEMA rating
5. Disassemble the motor
6. Remove centrifugal switch and inspect each part
7. Test the stator windings and identify leads
8. Test the capacitor for capacitance value and calculate the capacitance mathematically
9. Reassemble and check shaft manually for freedom of rotation
10. Connect to proper power source and operate
11. Measure voltage, amperage, and wattage on both high- and low-voltage hookups
12. Reverse rotation on both high- and low-voltage hookups

   - c. Series dual-main windings for high voltage
   - d. Parallel dual-main windings for low voltage

9. Reversing a dual-voltage capacitor motor
   - a. Parallel dual-voltage main windings and starting for low voltage
   - b. Series dual-voltage main windings and parallel starting winding with one main winding for high voltage
     CAUTION: Capacitor should operate for short intervals on low voltage only.

10. Repairs: mechanical and electrical
    - a. Worn or tight bearing
    - b. Overload devices
    - c. Centrifugal switch
    - d. Defective capacitor

XXVIII. TROUBLESHOOTING INFORMATION FOR SPLIT-PHASE AND CAPACITOR-START MOTORS

Trade Knowledge

References

1. Failure to start (motor completely dead)
   - a. Fuse blown
   - b. Power off
   - c. Overload protector tripped

Trade Practice Time 24 hours

Job

Troubleshoot split-phase and capacitor-start motors

Safety

Take the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

VOM
Meter, clamp-on-type
Screwdriver, flat blade; 6"
Screwdriver, Phillips #2
Nut driver set

Procedure

1. Check fuses
2. Check voltage at motor terminals

   d. Internal connections either broken or loose

2. Motor failure to start (hums and attempts to start)

   a. Low voltage
   b. Faulty centrifugal switch operation
   c. Capacitor failure, shorted or open circuit
   d. Stator windings defective or grounded
   e. Improperly connected motor
   f. Bearing tight or frozen
   g. Excessive load
   h. Rotor rubs stator

4. Overheating

   a. Incorrect voltage
   b. Faulty centrifugal switch operation
   c. Stator winding grounded or shorted
   d. Improperly connected
   e. Bearing tight
   f. Motor overload
   g. Excessive ambient temperature

5. Excessive bearing wear

   a. Improper mounting
   b. Improper lubrication

6. Noisy operation

   a. Loose external or internal parts
   b. Excessive end play
   c. Worn rubber mountings
   d. Loose pulley or coupling
   e. Improper mounting or alignment with driven unit
   f. Transmitted vibrations

7. Motor shocks when touched--stator grounded

3. Push reset button, manual-type overload protectors; automatic overload protector will automatically reset itself when motor returns to a safe temperature
4. Disconnect motor from the line and make a continuity check of the circuit through the motor, using a VOM
5. Check connections at switch contact plate and terminal plate
6. Check main and phase windings separately
7. Measure voltage at motor terminals
8. Uncouple motor from load, close the line switch; if motor comes up to correct speed or if the motor starts itself only in certain positions, the centrifugal switch mechanism should be checked
9. Check the capacitor and replace if defective
10. Use the VOM to check for ground across the common stator lead and the frame
11. Check amps input to the motor with clamp-on-type meter and compare meter reading with nameplate data (high amperage reading indicates a shorted winding)
12. Check wiring diagram for proper connections (some motors have wiring diagram on nameplate)
13. Attempt to turn motor shaft by hand; if tight or frozen, add oil; if it is rough, replace
14. Examine load unit for evidence of overload conditions
15. Check for worn bearings or cracked end frames
16. Check the power supply to see if the voltage, frequency, and amperage capacity are in accord with the frequency nameplate data
17. Check governor weight to see that it slides freely on switch pin
18. Check switch on top of contact mounting screw
19. Check contacts for pits or for being welded together
20. Using VOM, check for ground across the common stator lead and frame

21. Check amperage input to the motor with clamp-on-type ammeter and compare with rated amps on the motor nameplate (high-amp reading, indicates shorted winding)
22. Connect the motor to the power line according to the wiring diagram; be sure all connections are correct electrically and mechanically tight
23. Turn motor shaft by hand; if tight or frozen, add oil; if bearing is rough, replace
24. Measure motor input in amps with clamp-on-type ammeter and compare meter reading with nameplate data on motor
25. Check for tight bearing or a rough bearing
26. Check the temperature of surrounding air with thermometer and see if temperature is too high for operating conditions
27. Check manufacturers' data for correct belt tension
28. Check motor shaft by hand for free rotation or rough bearing and oil if necessary
29. Check cover plate and capacitor mounting box
30. Add thrust or spacer washers
31. Replace mountings if they are gummy or hard and brittle
32. Check for mechanical wear and check to see that pulley is securely fastened to shaft
33. Improper alignment produces excessive bearing wear, shaft wear and vibrations. Check motor mounting
34. Remove motor from driven unit and run motor separately on a solid surface to determine if the motor is the source of the vibration
35. Check for ground across the common stator lead and the frame
36. Check amperage input to the motor with a clamp-on-type ammeter and compare reading with nameplate data; high amperage indicates a shorted winding

XXIX. A-C MOTORS: UNIVERSAL TYPE

Trade Knowledge

References

(8) RSA#10 Job #10
(13) chapter 9, p 243

1. General description of universal motor
2. Types
    a. Two-pole
    b. Distributed-field, compensated
    c. Single-field, compensated
    d. Two-field, compensated
3. Purpose and application of each type
4. Use of drawings, specifications, manufacturers' catalogs, handbooks, and service manuals to determine
    a. Type and size
    b. Voltage and amperage rating
    c. Connections
    d. Nameplate data
5. Construction
    a. Main parts
    b. Frame
    c. Field and core
    d. Armature
    e. End plates

Trade Practice

Time 12 hours

Job

Service or make minor repairs on a universal motor

Safety

Take necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

Motor, universal; 1/8-hp
Coil, choke
Growler
VOM
Screwdriver, 4"
Nut driver set
Hammer, soft head

Procedure

1. Draw a schematic diagram for a universal motor
2. Explain the operation of the motor
3. Identify the principal parts and explain the function of each
4. Use drawings, specifications, manufacturers' catalogs, handbooks, and service manuals to determine
    a. Type and size
    b. Voltage and amperage rating
    c. Connections
    d. Nameplate data
5. Make visual inspection, note external characteristics, read nameplate, and analyze data
6. Disassemble for an electrical and mechanical check
7. Make electrical bench check for continuity, shorts, open, and grounds
8. Replace and/or repair faulty electrical parts
9. Apply lubricant to bearing if needed and reassemble
10. Check work for completeness
11. Use a wiring diagram or blueprint to wire equipment in a circuit

6. Electrical operation
    a. Field coils and minor coils connected in series
    b. Reaction between magnetic lines of force in field and armature
7. Connecting the field coils and armature
8. Reversing the universal motor
    a. By reversing current through armature
    b. By reversing current through field coils
    c. By relocating leads on commutator
9. Use of growler

11. Use a wiring diagram or blueprint to wire equipment in a circuit
12. Make an rpm test
13. Vary speed by use of
    a. Choke coil
    b. Tap-field coil
    c. Governor (centrifugal)

NOTE: Avoid excessive motor speed.

XXX. A-C MOTORS: SHADED-POLE TYPE

Trade Knowledge

References

(13) chapter 9

1. General description
2. Types
    a. Two-pole
    b. Four-pole

Trade Practice Time 12 hours

Job

Service or make minor repairs on a shaded-pole motor

Safety

Tools, Equipment, Supplies

Motor, shaded-pole; approximately 200 watts
VOM
Ammeter, clamp-on-type
Tachometer
Tags, identification
Wattmeter
Screwdriver, 6"
Hammer, soft head
Nut driver set

Procedure

1. Draw a schematic diagram for a four-pole, shaded-pole motor with field plates connected in series for alternate polarity

3. Purpose and application
4. Use of drawings, specifications, manufacturers' catalogs, and handbooks to determine
    a. Type and size
    b. Voltage and amperage ratings
    c. Speed
    d. Connections
    e. NEMA rating
5. Parts and function of parts
    a. Rotor
    b. Stator
    c. End plates
    d. Shading rings
6. Operation of shaded-pole motor
    a. Rotor winding
    b. Stator winding
    c. Shading coil
7. Analyzing motor troubles
    a. Mechanical
        (1) Excessive wear: shaft, bearing, other
        (2) Freedom of rotation: shaft, bearing
        (3) Centrifugal switch
    b. Electrical
        (1) Ground
        (2) Open winding
        (3) Short
8. Reversing a shaded-pole motor by removing the stator and shifting the stator 180° (end for end)
9. Repairs: mechanical, electrical
    a. Worn or tight bearings
    b. Overload device

2. Explain operation of shaded-pole motor
3. Identify principal parts and explain function of each
4. Use drawings, specifications, manufacturers' catalogs, and handbooks to determine the following characteristics of shaded-pole motor
    a. Type and size
    b. Voltage and amperage rating
    c. Speed
    d. Connection
5. Disassemble the motor
6. Remove and inspect each part
7. Test windings and identify the leads
8. Reassemble and manually check the shaft for freedom of rotation
9. Connect to the proper power source and operate
10. Measure voltage, amperage, and wattage of motor and compare with nameplate data
11. Reverse the rotation of the motor

DOMESTIC REFRIGERATION

I. PRINCIPLES OF REFRIGERATION

Trade Knowledge

References

(3) pp 1-56
(11) pp 16, 21-50, and fold-out chart in back of text

1. History of refrigeration
   a. Refrigeration in industry
   b. Absorption refrigeration
   c. Automatic refrigeration
   d. Automotive air conditioning
   e. Equipment cooling
2. Physics
   a. Natural laws of
      (1) Mechanics
      (2) Forces
      (3) Matter
      (4) Light
      (5) Sound
      (6) Pressure
      (7) Gases
      (8) Heat
      (9) Temperature
3. Heat
   a. Definition of heat
   b. Heat as form of energy
4. Measurement of heat
   a. Thermometers
   b. British thermal unit (Btu)

Trade Practice

Time 24 hours

Job

Determine the correct refrigerant charge

Safety

CAUTION: Do not fill service cylinder over 85% of its capacity

Tools, Equipment, Supplies

Large cylinder of refrigerant
Gas
Scales
Cylinder, service
Connecting line, 1/4", and valves

Procedure

1. Draw a simple refrigeration system and use the graphic symbols for each part
2. Explain the function of each part
3. Transfer refrigerants from a large cylinder to a smaller cylinder
4. Mount larger cylinder in inverted position so that the cylinder valve is accessible
5. Run a 1/4-inch service line from large cylinder to the service cylinder
6. Place small cylinder on set of scales
7. Determine the approximate amount of refrigerant gas in the service cylinder by weight
8. Do not fill service cylinder over 85% full

5. Type of heat
    - a. Sensible heat
    - b. Latent heat
    - c. Latent heat of melting
    - d. Latent heat of vaporization
    - e. Superheat
    - f. Liquid freezing point
    - g. Vapor condensate point

6. Heat transfer
    - a. Conduction
    - b. Convection
    - c. Radiation

7. Measurement of heat intensity
    - a. Fahrenheit scale
    - b. Centigrade scale

8. Pressure
    - a. Meaning of pressure
    - b. Pressure as applied to refrigeration

9. Pressure measurement
    - a. Absolute scale
    - b. Standard (gage) scale
    - c. Compound scale
    - d. Mercury scale
    - e. Small pressures

10. Gas laws
    - a. Charles' law
    - b. Boyles' law
    - c. Dalton's law

11. Refrigeration cycle
    - a. Liquid receiver
    - b. High-pressure gas
    - c. Liquid line
    - d. High-pressure liquid
    - e. Refrigeration control valve
    - f. Evaporation
        - (1) Absorption of heat
        - (2) Liquid to gaseous state
    - g. Suction line
    - h. Low-pressure gas
    - i. Compressor
        - (1) Low-pressure side
        - (2) High-pressure side

- j. High-pressure gas
- k. Condenser
- l. High-pressure liquid
- m. Returning to receiver as high-pressure liquid

12. Refrigeration system components
    - a. Compressor
        - (1) High-side
        - (2) Low-side
    - b. Condensers
        - (1) Metal cooling fins
        - (2) Metal tubing
    - c. Evaporator
    - d. Refrigerant control
    - e. Receiver

II. REFRIGERANTS

Trade Knowledge

References

(1) pp 56-57

1. Refrigerant characteristics
    - a. Nonpoisonous
    - b. Nonexplosive
    - c. Noncorrosive
    - d. Nonflammable
    - e. Easily detected by lead detector
    - f. Operation under low pressure
    - g. Stable gas

Trade Practice — Time 12 hours

Job

Use halide leak detector in checking for leaks in a simple refrigeration system

Safety

1. Avoid getting liquid on skin
2. Avoid getting liquid in eyes
3. Avoid inhalation of vapor or gas
4. Never fill refrigerant cylinder over 85% of capacity

Tools, Equipment, Supplies

Leak detector, halide
Refrigeration system

Procedure

1. Open the adapter needle valve 1/16 to 1/8 of a turn
2. Light the flame detector tip
3. Using needle valve, adjust flame to approximately one inch
4. Observe the reactor place until it becomes cherry red
5. Using needle valve, adjust flame to about 5/8"

h. Nondestructive to the lubricating properties of oil
i. Nontoxic
j. High latent heat of evaporation
k. Relatively small displacement per pound of liquid refrigerant

2. Types of refrigerants

a. Ammonia, NH_3, R-717
b. Sulphur dioxide, SO_2, R-764
c. Methyl chloride, CH_3Cl, R-40
d. Trichloromonofluoromethane, CCl_3, R-11
e. Dichlorodifluoromethane, CCl_2F_2, R-12
f. Monochlorodifluoromethane, $CClF_3$, R-13
g. Monochlorodifluoromethane, $CHClF_2$, R-22

3. Hydrocarbon refrigerant

a. Methane, R-50
b. Ethane, R-170
c. Butane, R-600
d. Isobutane, R-600A

4. Refrigerant color codes

a. Ammonia ... white
b. Sulphur dioxide ... black
c. Methyl chloride ... red
d. R-11 ... orange
e. R-12 ... white
f. R-13 ... black
g. R-13B1 ... black
h. R-22 ... green

5. First aid when using refrigerants

a. Liquid on skin
b. Liquid or vapor in eyes
c. Vapor or gas inhalation

6. Care in handling refrigerant cylinders

a. Never drop cylinder
b. Tie cylinder securely when transporting
c. Close all valves tightly
d. Use protective caps on cylinders
e. Never mix refrigerants
f. Never put anything except refrigerant in a cylinder

6. Explore for leaks by moving the end of the suction hose very slowly around all joints and connections
7. Observe flame for a color change as small leak will produce a blue-green flame and a large leak is indicated by a purplish-blue flame

  - g. Never use cylinders for rollers or supports
  - h. Never attempt to repair cylinder
  - i. Never permit flame to come in contact with cylinder
  - j. Never fill a cylinder over 85% full

7. Temperature charts
   - a. Converting temperature to pressure
   - b. Converting pressure to temperature
   - c. Variation in types of refrigerants according to pressure

III. EVACUATING A DOMESTIC UNIT

Trade Principles

References

(1) p 396
(8) Job #16

1. Installation of manifold and gages
   - a. Connections to SSV
   - b. Connections to DSV
   - c. Installation of one-half union
   - d. Purging the air and moisture from manifold and lines
2. Service and testing operation with manifold system all in one

Trade Practice Time 6 hours

Job

Evacuate a domestic unit

Safety

Tools, Equipment, Supplies

Manometer
Services gages, 1 set
Pump, vacuum; 10 microns or more
Wrench, adjustable; 8"
Hermetic kit; if applicable
Wrench, ratchet; 1/4"
Extension cord, 12-3; 50'

Procedure

1. Install manifold gages
   - a. Connect one side of manifold to SSV, using 1/4" tubing
   - b. Connect one side of manifold to DSV, using 1/4" tubing
   - c. Install two 1/8" MP x 1/4" in MF half unions in service valve
   - d. Turn valve stems all the way out

    - a. Observing operating pressures
    - b. Charging refrigerant through compressor
    - c. Purging recliner
    - d. Changing liquid into high side
    - e. Building up pressure in low side for control settings or testing for leaks
    - f. Charging oil through the compressor
3. Installation of hermetic kits
4. Use of vacuum pumps
    - a. Evacuating commercial system
    - b. Evacuating domestic system
5. Selection of vacuum pumps
    - a. .1 micron pump
    - b. 10 micron pump
6. Effects of temperature upon evacuation of a system
7. Techniques used in opening high-pressure valve when connected to a gage
8. Correct reading of gages
    - a. Familiarization of gage markings
    - b. Interpretation of gage readings between markings on gage
9. Importance of evacuating system to a vacuum as low as possible
10. Removing of moisture from the system at low-vacuum readings
11. Reading a manometer

    - e. Clean valve externally before reaming the pipe line plugs and installing the half unions
    - f. After the half unions are installed in gage opening, connect lines from the manifold to the fittings
    - g. Leave line to SSV loose by two turns
    - h. Tighten line to DSV
    - i. Open both manifold valves 1/4 to 1/2 turn and cap middle opening
    - j. Purge manifold system
    - k. Tighten all fittings and test for leaks
2. Install hermetic kit if applicable
3. Install vacuum pump (10 microns or better)
4. Check high side gage for damage to gage
5. Check compound gage for degree (or inches) of vacuum
6. Check with instructor for further instructions in reference to amount of time that system is to be evacuated
7. Use manometer in step three if available

IV. CHARGING AN OPEN-TYPE SYSTEM

Trade Knowledge

References

(1) pp 283, 128, 495
(2) pp 264, 268
(8) Job #16

Trade Practice   Time 12 hours

Job

Charge an open-type domestic system

Safety

Wear goggles when working with high-pressure lines
CAUTION: Do not charge into high side of system. This is dangerous because excessive pressure may be produced.

1. Installation of service gages and manifold
2. Installation of vacuum pump
3. Evacuation of domestic system
4. Installing a gage manifold
5. Purging a line to eliminate air and moisture
6. Testing for leaks with halide torch or electronic leak tester
7. Adding refrigerant to system from the suction side
   a. Length of charging line
   b. Weight of cylinder
   c. Position of cylinder
   d. Pressure of cylinder
   e. Opening of valves
   f. Starting of compressor
   g. Regulating flow of refrigerant from cylinder
8. Sight glass
   a. Provides method of checking for refrigerant quantity
   b. Mounded in liquid line
   c. Bubbles give certain indications of the refrigerant
9. Use of proper wrenches in working with valve stems and gages

Tools, Equipment, Supplies

Manifold, gage, complete
Pump, vacuum; 10 microns or better
Wrench, ratchet
Tube, changing
Tester, leak
Goggles
Cylinder, refrigerant; 5 lbs.
System, refrigerating

Procedure

1. Install service gages
2. Install vacuum pump (10 microns or better)
3. Evacuate system properly
4. Connect service cylinder access line on gage manifold (middle opening of manifold)
5. Connect access line to refrigerant system; purge the line and test for leaks
6. Start compressor with the DSV turned all the way in (CAUTION: this should be done only for a short period of time to build up pressure in the refrigerant cylinder)
   a. Open the cylinder valve very slowly at first
   b. Never allow low-pressure side to exceed the following pressures
      (1) 5 psi for sulphur dioxide
      (2) 15 psi for chloride
      (3) 25 psi for Freon-12
8. Check sight glass for proper charge
9. Remove gages and 1/8" pipe to 1/4" half unions if used in this procedure
10. Install 1/8" pipe plug on service point

V. INSTALL A TAP-A-LINE VALVE

Trade Knowledge

References

(1) p 387
(2) p 258

Trade Practice Time 3 hours

Job

Install tap-a-line valve

1. Suitable location of tap-a-line valve
   a. Locate near compressor
   b. Locate in accessible area
2. Techniques in cleaning copper tubing
3. Construction of tap-a-line valve
4. Importance of selecting correct size valve for copper line to be tapped
5. Operation of tap-a-line valve

Safety

Wear goggles when working with high pressures

Tools, Equipment, Supplies

Manifold, gage
Screwdriver, flat blade; 6"
Screwdriver, Phillips; 6"
Tap-a-line, 1/2"
Valve, line-tap
Soapsuds, one can
Steel wool
Window air-conditioning unit

Procedure

1. Select location for installation of tap-a-line valve and clean the area with steel wool
2. Install tap-a-line valve
3. Tighten needle seat until copper line is pierced
4. Test for leak, using soapsuds
5. Connect charging hoses

VI. REPAIR OF REFRIGERANT LEAKS

Trade Knowledge

References

(1) pp 38-41, 281
(2) pp 266-267
(3) pp 277-281

Trade Practice   Time 12 hours

Job

Locate and repair a refrigerant leak in a domestic unit

Safety

Wear safety goggles when using torch for repair. Caution should be used when lighting and using torch

Tools, Equipment, Supplies

Detector, leak; halide
Wrench, ratchet; 1/4"
Prest-O-Lite, B Tank; include regulator, hose, and torch
Arc striker
Refrigerant, one drum

1. Knowledge of testing for "R" and ethyl chloride leaks with halide torch
    a. Detector operates on acetylene and produces colorless flame
    b. Air tube of torch is brought near the leak and its presence is shown by brilliant green color of flame
2. Proper use and storage of halide torch
3. Soldering-brazing procedure
    a. Cleaning of area, mechanically
    b. Support of the tubing to be soldered
    c. Application of flux to match the silver brazing alloy
    d. Correct amount of heat to evenly heat the area to be soldered
    e. Application of silver solder as directed by instructions
    f. Proper cooling of soldered area
    g. Proper cleaning of soldered area
4. Knowledge of correct refrigerant charge
    a. Use of specification and charts for charging domestic units
    b. Effects of overcharging and undercharging a system
5. Knowledge of electrical system
    a. Reading of schematic diagrams
    b. Use of instruments to make proper electrical checks

Pump, vacuum; 10 microns
Kit, hermetic accessible
Cord, extension; #12, 3-wire (50 ft.)
Manifold and gages
Solder
Tubing; 3/16", 1/4", 1/16", 3/8", 1/2"

Procedure

1. Open acetylene cylinder
2. Light halide torch and allow torch to warm up
3. Check all refrigerant coils within the system for leaks, using the halide torch
4. Install hermetic kit and manifold gages
5. Check the pressure for approximately 10 psi
6. Repair leak
    a. Clean area to be soldered
    b. Apply solder, using sufficient heat to melt solder and heat repair area
    c. Cool repair area properly
    d. Clean repair area properly and thoroughly
7. Install solid core dryer
8. Evacuate system
9. Charge system
10. Check all work for completeness and operate unit

VII. SERVICE CYLINDER

Trade Knowledge

References

(1) pp 50, 300
(8) RSA#2 Job #1
(7) Job #18

1. Thermodynamics of bimetal refrigerant gases
2. Dangers involved in heating a cylinder or using a hot cylinder
3. Function of fusible and spring-loaded plugs
4. Proper capacity of refrigerant cylinder

Trade Practice Time 3 hours

Job

Charge a service cylinder

Safety

Wear goggles when working with high pressures. Do not drop refrigerant cylinder.

Tools, Equipment, Supplies

Scales, one set; weight to 150 lbs. (calibrated in ozs.)
Wrench, adjustable; 12"
Wrench, ratchet; 3/8"
Wrench, ratchet; 1/2"
Hose, refrigerant
Cylinder, service; small
Cylinder, storage; 145 lb.
Chiller, one drum

Procedure

1. Chill service cylinder
2. Set scales for accurate reading of weights
3. Install hose from storage cylinder to service cylinder on scales
4. Charge service cylinder to 85% capacity by allowing liquid refrigerant to flow from storage cylinder to service cylinder
5. Remove and replace storage cylinder

VIII. DRYERS

Trade Knowledge

References

(1) p 500
(11) pp 56-58

Trade Practice Time 6 hours

Job

Install a dryer

Safety

1. Wear goggles when working with high pressures
2. Bleed off all refrigerant gases into well-ventilated area

1. Installation of manifold gages
2. Knowledge of liquid lines and valves in domestic system
3. Pumping down a domestic system
4. Types of moisture indicators
5. Types of dryers
6. Function of dryer
7. Desiccant; chemical makeup
8. Types and sizes of dryers to be used with different types of refrigerants

Tools, Equipment, Supplies

Gages, service; one set
Tools, flaring; one set if applicable
Dryer
Cylinder, refrigerant
Wrenches, tubing
Tubing

Procedure

1. Install manifold gages
2. Close off liquid line
3. Pump down system
4. Close off suction line
5. Crack open flare nut on old dryer
6. Install new dryer, purge noncondensable gases from system
7. Place system back in operation

IX. HERMETIC COMPRESSOR

Trade Knowledge

References

(1) pp 375-400, 500
(2) pp 254-268
(8) Job #12

Trade Practice Time 24 hours

Job

Replace a hermetic compressor

Safety

1. Wear goggles
2. Provide proper ventilation
3. Observe precautions when working with acetylene torch
4. Observe necessary precautions for phosgene gas

Tools, Equipment, Supplies

Kit, hermetic
Gages, manifold; 1 set
Refrigerant, one drum
Prest-O-Lite; B Tank; complete, including torch, regulator, hose, and leak detector
Dryer, solid-core
Kit, acid clean-out
Compressor, new
Controls, electrical; new, as applicable
Pump, vacuum; 10 microns or more
Wrench, ratchet; 1/4"

1. Removal of a compressor
    a. Properly venting released refrigerant gas into the air
    b. Identification of electrical wires by tagging
    c. Methods of cutting tubing (do not use hacksaw, as metal filing will enter the system)
    d. Dismantling of compressor from the frame (care should be taken not to loosen mounting frame)
2. Knowledge of Group I refrigerants: Freon 113, methylene chloride, Freon -11, Freon -21, Freon 114, Freon -12, Carrene -7, Freon -22, Kulene 131, Carbon dioxide, Freon -13, Freon -14
3. Four basic functions of cleaning a refrigeration system are
    a. Water removal
    b. Acid removal
    c. Filtering out solids
    d. Indication of completed drying job
4. Techniques used in mounting compressor
    a. Bolting the compressor to the mounting frame
    b. Making the correct electrical connections
    c. Soldering of joints
    d. Cleanliness of work
5. Proper identification of electrical wiring and making necessary connections
6. Steps that may be used in evacuation
    a. Evacuation of the unit, using very good vacuum pump
    b. Charging system with CO_2 from 50 to 100 psi
    c. Re-evacuation of the unit
7. Reading of schematics of wiring diagrams
    a. Knowledge of electrical symbols
    b. Ability to trace complete circuit

Procedure

1. Remove old compressor
    a. Vent gas to atmosphere in a well ventilated area or to outside space
    b. Remove electrical connections and correctly identify each
    c. Cut tubing
    d. Remove the compressor
2. Install wash system, using Freon -11 refrigerant; pump system and/or install Sporlan acid; clean kit
3. Test acidity of system
4. Install new compressor
5. Evacuate the system
6. Make all electrical connections
7. Charge system with proper amount of refrigerant
8. Check for leaks
9. Check for proper sequence of operation
10. Check all work for completeness and cleanliness

8. Effects of overcharging and undercharging a system
9. Use of halide leak detector or an electronic leak detector
10. Use of manufacturers' data or operational procedure
11. Importance of checking work for completeness and cleanliness

X. CAPILLARY TUBE

Trade Knowledge

References

(1) pp 124-126
(2) pp 57, 220-230
(7) RSA#19 Job #19
(8) RSA#7 Job #20

1. Use and application of hand tools
2. Sizes and lengths of capillary tubes
3. Charging procedures
4. Knowledge of desiccants
5. Welding of capillary tubes

Trade Practice

Time 12 hours

Job

Test, remove or repair a capillary-tube refrigerant control

Safety

Wear goggles when working with high pressure

Tools, Equipment, Supplies

Detector, leak; halide
Wrench, ratchet; 1/4"
Scratcher, arch
Prest-O-Lite, B Tank; torch and solder if applicable
Tube, capillary; new
Dryer
Wrenches, tubing
Wrench, adjustable

Procedure

1. Install manifold gages
2. Pump down unit
3. Close off suction and receiver valves
4. Slowly remove flare nut to allow remaining refrigerant to escape
5. Install hydraulic pressure device for removing obstruction
6. Cut and splice capillary tube to remove obstruction
7. Replace capillary tube if unable to remove restriction
8. Connect flare nut
9. Install dryer
10. Pull vacuum
11. Open all valves

12. Check for correct charge
13. Check for leaks
14. Check for correct operation procedure
15. Weld if necessary

XI. AUTOMATIC EXPANSION VALVE

Trade Knowledge

References

(1) pp 77-103
(2) pp 220-230
(8) RSA#6 Job #17

1. Proper function of auto-expansion valve
2. Proper use of halide leak detector
3. Knowledge of use of hand tools
4. Component parts of automatic expansion valve
5. Proper procedure for removal of moisture, air, and noncondensable gases
6. Desiccant types of dryers and their chemical makeup
7. Cost factor in replacing or repairing a new valve

Trade Practice Time 9 hours

Job

Repair and/or replace an automatic expansion valve

Safety

Wear goggles when working with high pressure

Tools, Equipment, Supplies

Pump, vacuum; optional
Gages, manifold (1 set)
Refrigerant
Valve, expansion; new
Wrenches, tubing
Dryer

Procedure

1. Install manifold gages
2. Close receiver valve and pump down the refrigerant into the receiver
3. Pull disconnect switch to motor
4. Close suction valve
5. Slowly purge off refrigerant vapor
6. Remove and check valve for defects
7. Repair or replace expansion valve
8. Upon replacing valve, purge to remove air and noncompressible gases
9. Tighten flare nuts
10. Check system for leaks
11. Open suction and receiver valves
12. Energize - disconnect
13. Check refrigerant of system
14. Add dryer if applicable

XII. THERMOSTATIC EXPANSION VALVE

Trade Knowledge

Trade Practice Time 24 hours

References

(1) pp 106-116
(7) RSA#18 Job #17
(8) RSA#6

1. Operation of constant superheat expansion valve
2. Proper use of halide leak detector
3. Knowledge of use of hand tools
4. Component parts of thermostatic control valve
5. Proper removal of noncondensable gases
6. Desiccants - types and chemical makeup

Job

Test, remove, or repair a thermostatic expansion valve

Safety

Wear goggles when working with high pressures

Tools, Equipment, Supplies

Pump, vacuum
Gages, manifold; 1 set
Dryer, if applicable
Valve, thermostatic expansion; new
Wrenches, tubing

Procedure

1. Install manifold gages
2. Pump system down
3. Remove thermostatic bulb
4. Pull disconnect switch
5. Close suction valve on compressor
6. Slowly bleed off remaining vapor at expansion valve
7. Remove valve
8. Check
    a. Power element
    b. Needle seat
    c. Strainer
    d. Push pens
    e. Spring
    f. Superheat adjustment
9. Repair expansion valve or replace expansion valve if necessary
10. Replace system in operating order

XIII. REPAIR OF TEMPERATURE CONTROLS

Trade Knowledge

References

(1) p 141

Trade Practice Time 12 hours

Job

Repair of bimetal and thermostatic temperature controls

Safety

1. Theory of dissimilar metals
2. Making and breaking of circuit by use of bimetal control

Thermostatic control

1. Temperature-pressure relationship on thermostatic controls
2. Explanation of spring tension versus bellows
3. Calibration of thermostats
4. Making and breaking of circuit, using thermostatic control

Tools, Equipment, Supplies

Thermometer, calibrated
Sand cloth
Screwdriver, small
Control, temperature; bimetal
Control, thermostatic temperature

Procedure

(Bimetal control)

1. Check calibration of bimetal control
2. Inspect contact for pits
3. If necessary, use sandpaper to smooth contact points
4. Check for continuity of circuit when switch opens and closes

(Thermostatic control)

1. Check power element of temperature control
2. Check contacts for pits
3. Sand contact points if necessary
4. Calibrate thermostat
5. Check differential swing, approximately three degrees (3°)
6. Check continuity of control where contacts make and break

XIV. HOT-WIRE START RELAY

Trade Knowledge

References

(1) pp 142, 149
(11) p 295

Trade Practice Time 6 hours

Job

Test and/or replace a hot-wire relay

Safety

Observe the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

Meter, clamp-on-type
Relay, hot-wire
Wrenches, nut driver; one set
Screwdriver, 6"
Screwdriver, 1 1/2"
Kit, relay test
Cord, extension

1. Types of hot-wire relays
2. Operation of hot-wire relay
3. Purpose of hot-wire relay
4. Use of time-delay relays
5. Techniques of checking a hot-wire relay
6. Repair of a relay
7. Cleaning and filing contacts
8. Interpretation of nameplate data on relay
9. Use of manufacturers' catalogs for ordering replacements and showing connections of a hot-wire relay

Procedure

1. Disconnect wires from relay
2. Label and/or correctly identify each wire
3. Check relay for weak hot-wire element
4. Check relay for burned or dirty contacts
5. Repair or replace the relay
6. Connect repaired or new relay in circuit
7. Check work for completeness
8. Operate the system and check proper friction of the relay

XV. HOT-GAS DEFROST

Trade Knowledge

References

(1) pp 137, 366-369, 444

1. Types of hot-gas defrost systems
2. Operation of hot-gas defrost system
3. Purpose of defrost system
4. Use of solenoid valves
5. Thermodynamics of refrigerant gases
6. Electrical circuits used with hot-gas defrost systems

Trade Practice Time 12 hours

Job

Test and/or repair a hot-gas defrost

Safety

Wear goggles when working with high pressures of refrigerant

Tools, Equipment, Supplies

Screwdrivers, one set
VOM
Tester, voltage
Control, hot-gas defrost

Procedure

1. Turn unit to defrost cycle
2. Remove solenoid valve
3. Check operation of solenoid
4. Check voltage to solenoid
5. Check for sticking valve
6. If solenoid is sticking, clean system
7. Reassemble defrost-system components
8. Check all work and connections for completeness
9. Operate system and check the function of the defrost system

XVI. ELECTRIC DEFROST

Trade Knowledge

References

(1) pp 372, 447
(2) Manufacturers' Manuals and catalogs

1. Types of electrical defrost systems
2. Operation and function of electrical defrost system
3. Techniques used in checking a defrost system
4. Reading of schematics
5. Types of fan motors
6. Operation of fan motors
7. Repair of fan motors

Trade Practice

Time 18 hours

Job

Test, repair and/or replace an electric defroster

Safety

Observe the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

VOM
Wire, heater
Timer, defrosting
Gun, soldering; electrical: 250 watts
Motor, fan
Cord, extension
Wire, copper; electrical (1 roll of #16 standard).
Terminals, electrical; (1 set)
Tape, electrical (1 roll)

Procedure

1. Check electrical outlet for proper voltage
2. Check power - internal hookup to heater
3. Remove wires connecting to heater
4. Identify each wire and terminal
5. Check heater wire with VOM
6. If heater wire is defective, replace or repair
7. Clean and/or adjust contacts
8. Adjust timing mechanism
9. Replace timer if defective
10. Check timer gears
11. Reassemble
12. Check circulating fan blades
13. Check circulating fan motor
14. If motor is defective, check for lack of oil, short, opens, grounds, broken lead wire
15. Reassemble fan motor or replace motor
16. Check work for completeness
17. Operate unit and check the system for proper operation

XVII. AUTOMATIC ICE MAKER

Trade Knowledge

References

(1) pp 345, 418

1. Types of ice makers
2. Purpose and application of ice maker units
3. Float controls as used with ice makers
4. Temperature controls as used with ice makers
5. Use of manufacturers' catalogs for different makes of ice makers
6. Use of schematics to identify wiring and controls of automatic ice maker

NOTE: The use of manufacturers' data is almost essential when working with automatic ice makers because of the number of models, name brands, etc.

Trade Practice

Time 18 hours

Job

Check, test and/or repair an automatic ice maker

Safety

Observe the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

VOM
Cord, extension; 12-3
Tape, electrical (1 roll)
Kit, terminal connector

Procedure

1. Check for correct voltage at wall outlet
2. Check for broken wires
3. Check water level control
4. Check temperature control
5. Check heater wire
6. Check motor that rotates ice tray

XVIII. INSTALLATION OF DOOR SEALS AND ADJUSTMENT OF DOORS

Trade Knowledge

References

(1) pp 226-234
(2) p 299
(8) RSA#12 Job 24

Trade Practice

Time 9 hours

Job

Install door seal and adjust door of domestic unit

1. Types of gaskets and purpose of each type
    a. Standard rubber gasket
    b. Magnetic rubber gasket
    c. Plastic gasket
2. Techniques used in removing doors and gaskets
3. Handling of door and other parts so as to prevent damage to finish of refrigeration unit
4. Methods of installing door gaskets
    a. Clamping
    b. Use of adhesives
5. Adjustment of gasket and door
6. Techniques used in checking the proper fit of gasket

Safety

Avoid excessive lifting

Tools, Equipment, Supplies

Refrigeration unit
Cutting tool, gasket
Gasket, new
Drop cloth
Hand tools, assorted

Procedure

1. Remove plug from wall outlet
2. Remove door from refrigerator
3. Place drop cloth on floor or table so that door may be positioned on the drop cloth
4. Lay door on cloth
5. Remove "O" gasket by removing screws or clips
6. Take gasket cutting tool, lay out old gasket and new gasket, and cut at proper places
7. Re-install gasket
8. Re-install door
9. Adjust gasket clearance on door seal and hinges
10. Check work for completeness and place unit in operation

XVIX. INSTALLATION OF DOMESTIC ELECTRIC UNIT

Trade Knowledge

References

(1) pp 221-242
(3) pp 307-318
(8) RSA#8

Trade Practice Time 12 hours

Job

Install and check a domestic electric unit

Safety

Technique of lifting with a dolly

Tools, Equipment, Supplies

Dolly, household
Level
Pliers, channel-lock
Wrench, open end; 1/2" - 9/16"
Wrench, adjustable

1. Procedure for removing shipping bolts and block
2. Electrical circuitry of household unit
3. Methods of adjusting magnetic door closure
4. Proper adjustment of temperature range on household unit

Ratchet, 3/8" drive; 1/2", 9/16" socket
Refrigerator, domestic
Meter, clamp-on-type
Drop cloth

Procedure

1. Remove shipping bolts
2. Set refrigerator in position
3. Adjust to level both ways
4. Check voltage at plug
5. Plug into receptacle
6. Check amperage of the unit
7. Check door seal
8. Check interior light
9. Check temperature
10. Correct the thermostat setting
11. Check exterior wall for condensation

XX. INSTALLATION OF AN ABSORPTION UNIT

Trade Knowledge

References

(1) pp 325-347
(2) pp 8-17, 175, 178, 180, 181
(8) RSA#5

1. Locating absorption unit so that a correct draft for air circulation is possible

Trade Practice Time 36 hours

Job

Install an absorption refrigerator

Safety

Danger of

a. Burns
b. Explosions
c. Deadly gas

Tools, Equipment, Supplies

Dolly, household
Level
Hand tools, arcless
Wrenches, pipe
Threaders, pipe
Tubing, copper
Fittings
Wrenches, adjustable

Procedure

1. Using a dolly, move refrigerator to its proper location

2. Operation of absorption system and its components
    a. Ammonia vapor
    b. Separator
    c. Liquid heat exchange
    d. Absorber
    e. Analyzer
    f. Rectifier
    g. Condenser
    h. Evaporator
    i. U tube
    j. Cooling coil
3. Connecting an absorption unit
    a. Use of 3/8" copper or aluminum tubing
    b. Locating tubing for protection
    c. Locating unit as close to gas outlet as possible
    d. Installation of hand shutoff between main gas line and tubing
    e. Installation of strainer at the outlet of the shutoff cock
4. Use of different types of fittings necessary to install a unit, using 3/8" tubing
5. Techniques used in purging air from lines
6. Knowledge of different gases and fuels
    a. Natural
    b. Butane
    c. Propane
    d. Kerosene
7. Types of orifices to be used with
    a. Natural gas
    b. Butane
    c. Propane
8. Types of burners
    a. Type A - for fast-burning gas
    b. Type D - for slow-burning gas
9. Adjustment of burner to obtain correct distance from generator flue

2. Level refrigerator (leveling should be as nearly perfect as possible)
3. Connect gas connections and water lines for automatic ice maker (if used)
4. Purge air from lines
5. Light pilot
6. Adjust flame
7. Check for proper operation procedure

XXI. GAS REGULATOR

Trade Knowledge

References

(2) p 180

1. Types of control valves
   a. Gas volume
   b. Safety control
2. Pressure - temperature control bulb
   a. To regulate gas flow
   b. To work in conjunction with volume control
3. Manual adjustment
   a. To increase flow of gas
   b. To decrease flow of gas
4. Safety control
   a. To prevent the waste of gas
   b. To protect against other dangers when gas is extinguished
5. Resetting safety control by use of reset button
6. Effects on refrigeration cycle when large amounts of heat are used

Trade Practice

Time 6 hours

Job

Adjust the gas regulator

Safety

Take precautions against burns and explosions. Take necessary precautions to prevent the escape of any deadly gas

NOTE: Extreme caution should be used when working with gas volume control, because of collection of gas and danger of explosion

Tools, Equipment, Supplies

Screwdriver, arcless
Wrench, adjustable; arcless
Pliers, plastic; arcless
Absorption unit with regulator valve

Procedure

1. Check for constant gas pressure to regulator valve
2. Consult manufacturers' catalogs or service manual for adjustment specification for control valve being adjusted
3. Adjust flame control by turning adjustment screws for the type of flame desired

XXII. ELECTRICAL HEATING ELEMENT

Trade Knowledge

References

(2) p 181

1. Types of electrical heating elements used in domestic absorption units
   a. Resistance wire or strip
   b. Light bulbs
2. Techniques in checking resistance heating elements
3. Reading of schematics and wiring diagrams
4. Use of manufacturers' catalogs and service manuals to obtain necessary data for replacement parts

Trade Practice

Time 6 hours

Job

Install electrical heating element

Safety

Take necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

VOM
Light, trouble
Cord, extension; 12-3
Unit, with electrical heating element
Hand tools, assorted

Procedure

1. Remove electrical plug from wall outlet
2. Remove old heating element
3. Install new heating element, resistance-type or light bulb
4. Check schematic for proper electrical connection to heating strip
5. Check all work for completeness, plug in unit to electrical outlet and operate

XXIII. AUTOMATIC CONTROL VALVES, THERMO-COUPLE PILOT OPERATED

Trade Knowledge

References

(1) pp 335- 347
(2) p 180

Trade Practice

Time 9 hours

Job

Adjust and/or repair automatic control valve (thermocouple pilot operated)

Safety

Take necessary precautions to prevent burns, danger of deadly gas, and possible explosion

1. Types of thermocoupled automatic valves
2. Techniques in removing automatic control valves
3. Importance of correct size of orifice and effect upon the system when orifice size is changed
4. Techniques of checking safety valves by heating and cooling
5. Installation of safety valve and orifice

Tools, Equipment, Supplies

Unit, absorption; with thermocoupled automatic expansion valve
Light, trouble
Prest-O-Lite B Tank; complete unit
Mirror
Hand tools, assorted

Procedure

1. Cut off gas
2. Remove valve
3. Check orifice for cleanliness
4. Check safety valves with torch (if safety valve is operating properly, orifice is not worn)
5. Reinstall valve unit
6. Adjust air-port and gas-mixture valve to proper flame setting
7. Check all work for completeness and place unit in operation

XXIV. REPLACE THERMOSTAT

Trade Knowledge

References

(1) pp 342-343
(2) p 180

1. Type of capillary tubes used in domestic absorption system and their function
2. Techniques used in replacing a capillary tube

Trade Practice Time 9 hours

Job

Check and/or replace thermostat

Safety

Take necessary precaution to prevent escaping of gas and creating an explosive hazard

Tools, Equipment, Supplies

Refrigeration unit, absorption
Assembly, thermostat; applicable to the unit being serviced
Light, trouble
Hand tools, assorted

Procedure

1. Check gas-filled capillary tube
2. Replace entire assembly if tube has lost charge
3. Turn off the gas
4. Remove entire thermostat assembly

3. Techniques used in the installation of a thermostat
4. Explanation of how the thermostat controls the gas flame by regulating gas flow into the system

5. Install new thermostat
6. Adjust minimum flame adjustment screw and maximum adjustment screw
7. Check all work for completeness and check unit while in operation

XXV. FLUE BAFFLE ADJUSTMENT FOR DOMESTIC ABSORPTION SYSTEM

Trade Knowledge

References

(1) p 344

1. Purpose of flue to provide path for flame gases
2. How the twisted flue baffle helps make the heat transfer efficient
3. Sections of flue
    a. Horizontal
    b. Vertical
4. Techniques used in cleaning a flue
5. Effect of a partially blocked flue upon operation of system

Trade Practice Time 3 hours

Job

Clean and adjust baffles on flue

Safety

Take necessary precautions to prevent burns from gas flame

Tools, Equipment, Supplies

Hand tools, assorted
Brush, cleaning
Unit, absorption; domestic

Procedure

1. Turn off gas to the unit
2. Examine the flue for any type of foreign material
3. Use a brush to clean the horizontal flue
4. Use forced air to clean flue (where necessary)
5. Replace flue, all baffles, covers, etc.
6. Check to see that absorption unit is balanced for proper operation
7. Check all work for completeness and place unit in operation

XXVI. AUTOMATIC DEFROSTER

Trade Knowledge

References

(1) p 238
(2) pp 133, 195

Trade Practice Time 12 hours

Job

Troubleshoot and/or repair automatic defrost system

Safety

Take necessary precautions to prevent electrical shock

1. Use of VOM to check an electrical switch for proper operation
2. Measuring of nichrome wire or other resistance wire with VOM
3. Function of a timer in the defrost system and best time to defrost a unit
4. Use of wiring diagram to trace a defrost system
5. Function of complete defrost system and its component parts
    a. Heater
    b. Timer
    c. Defrost switch

Tools, Equipment, Supplies

Absorption system, domestic; with automatic defrost system
Heater, defrost
Timer, defrost
Switch, defrost
VOM
Hand tools, assorted
Wrenches, assorted

NOTE: Manufacturers' catalogs and service manuals should be used when replacing the automatic defrost system or any part of it.

Procedure

1. Check defrost switch with VOM
2. Use VOM to check resistance of the automatic defrost heater
3. Check function of automatic timer (if time is applicable to unit)
4. Replace any faulty parts of the defrost system
5. Use wiring diagram for checking all electrical connections
6. Check all work for completeness and place unit in operation

DOMESTIC AIR CONDITIONING

I. FUNDAMENTALS IN AIR CONDITIONING

Trade Knowledge

References

(5) pp 1-28

1. Composition of air
   a. Nitrogen 78%
   b. Oxygen 20%
   c. Noble gases 1%
   d. All others 1%
2. Changes in air volume
   a. Volume change
   b. Pressure change
3. Standard air
   a. Pressure, 14.7 psi at 70° F
   b. Volume 13.34 cubic feet
4. Dew point temperature
   a. Mixture of air and water vapor
   b. Effects of temperature
   c. Condensation
5. Relative humidity
   a. Grain - a unit measure of moisture
   b. Water vapor
   c. Saturated air

Trade Practice

Time __ Hours

Job

Define definition of terms

Safety

Tools, Equipment, Supplies

Procedure

Define the following terms:

1. Air conditioning
2. Refrigeration
3. Ventilation
4. Fahrenheit
5. Humidity
6. Relative humidity
7. Bimetallic strip
8. Dew point
9. Superheated steam
10. Dry bulb temperature
11. Wet bulb temperature
12. Centrigrade
13. Conservation
14. Mean temperature
15. Heat gain
16. Barometric pressure
17. Dehumidifying
18. Effective temperature
19. Saturated air
20. Standard atmospheric pressure
21. Nitrogen
22. Oxygen

d. Relationship between amount of moisture in the air and amount it could hold at same temperature and pressure

6. Wet bulb temperature
7. Heat exchange between air and water

II. PSYCHROMETRIC CHARTS

Trade Knowledge

References

(5) pp 29-90

1. Psychrometric chart
    a. Psychrometry
    b. Use of psychrometer
    c. Use of psychrometric chart
2. Air mixtures as related to psychrometric chart
3. Air measurement
    a. Manometer
    b. Velometer
    c. Pitot tube

Trade Practice Time __ Hours

Job

Determine the dew point temperature and dry bulb temperature of air; then use psychrometric chart to find other properties of air

Safety

1. Use caution when working with ether
2. Do not use ether near open flame or sparks

Tools, Equipment, Supplies

1	Dew point indicator apparatus
2	120°F thermometers
1	Aspirator bulb and tubing
1	Pint of ether

Procedure

1. Clean dew point apparatus
2. Clean glass window
3. Polish surfaces if necessary
4. Connect pump to inlet of dew point apparatus
5. Fill with 1/2 fuel ether
6. Mount thermometers
7. Obtain readings
8. Use psychrometric chart to determind other air properties

4. Pressures

   a. Static pressure
   b. Velocity pressure

5. Checking velocities of air in open spaces
6. Checking velocities of air at supply openings
7. Checking velocities of air at suction openings
8. Checking velocities of air inside ducts

III. CHECK THE REFRIGERANT CHARGE ON A HERMETIC UNIT

Time 1-1/2 Hours

Trade Knowledge	Trade Practice
References	Job
	Check the refrigerant charge on a hermetic unit
	Safety
	Wear safety goggles
	Tools, Equipment, Supplies
	1 Manifold gage set and charging hose 1 Hermetic unit 1 Line tap, 3/8" 1 Tap-a-line valve 1 Screwdriver 6" (flat blade) 1 Screwdriver 6" (Phillips) 1 Steel wool pad
	Procedure
1. Tap-a-line operation	1. Clean location on line
2. Operation of pressure gage	2. Install tap-a-line
3. Location of valve	3. Install gages
	4. Open tap-a-line

IV. EVACUATE A REFRIGERATION A/C SYSTEM

Trade Knowledge

References

(11) pp 261, 268
(11) pp 263, 264, 297, 396

1. Installation of manifold gages
2. Care and operation of vacuum pump
3. Purpose and principle of manometer
4. Types of manometer
    a. Open-tube type
    b. Dial type
5. Fluids used in manometer
    a. Water for low pressure
    b. Mercury for high pressures
6. Effect of reducing pressure to the boiling point of water
    a. Boiling of water at standard atmosphere and pressure

Trade Practice

Time 12 Hours

Job

Evacuate a refrigeration A/C system

Safety

Tools, Equipment, Supplies

1 Vacuum pump
1 Tubing cutter
1 Socket set, 1/4" drive
1 Manifold gage
1 Refrigeration system
1 Manometer
1 Nitrogen rig, tank and regulator refrigerant gas (cylinder that is applicable to unit)
1 Refrigerant gage hose
1 Prest-O-Lite torch
1 Dryer (applicable to system)

Procedure

1. Install manifold gages on valve ports and bleed the system
2. Connect vacuum pump and manometer at manifold gages
3. Evacuate system until fluid levels are equal; should the fluid levels not even out, check the system for leaks and repairs
4. Break the vacuum with nitrogen until pressure reaches +5 psi;evacuate the system
5. Repeat pressurization with nitrogen and evacuate unit until manometer is even; warm vapor with torch to dispel moisture
6. Break unit with refrigerant applicable to unit up to 5 psi
7. Install dryer

b. Boiling of water at low pressures

7. Purpose and installation of dryers

V. REPLACE A HERMETIC COMPRESSOR

Trade Knowledge

References

(1) pp 388-389
(2) p 144
(11) p 204-205

1. Silver soldering
2. Installation of test manifold gages
3. Operation of a vacuum pump
4. Charging kit
5. Operating pressures of gases
6. Different sizes of fittings
7. Use of pinch-off tools
8. Purpose, use, and care of thermometer

8. Evacuate and charge with proper refrigerant
9. Remove gage manifold

Trade Practice   Time __ Hours

Job

Replace a hermetic compressor

Safety

Wear goggles when working with high pressure refrigerant
Wear goggles when working with torch

Tools, Equipment, Supplies

1 - Hermetic system
1 - Replacement compressor of correct specifications
1 - Manifold gage set and hoses
1 - Prest-O-Lite
1 - Silver solder and flux
1 - Vacuum pump
1 - Charging kit
1 - Refrigerant charging cylinder
1 - Tubing cutter
1 - Steel wool
1 - Pinch-off tool
1 - Thermometer
1 - 9/16" x 1/2" box end
1 - 8" adjustable wrench
1 - 3/8" sweat coupling
1 - 1/4" sweat coupling

Procedure

1. Clean location for valve
2. Install valve

3. Install manifold gages
4. Remove refrigerant
5. Cut compressor lines
6. Remove compressor hold-down bolts
7. Remove electrical connections
8. Remove compressor

9. Location of valve attachment kit
10. Pressure-leak testing with nitrogen

9. Replace new compressor
10. Replace hold-down bolts
11. Connecting compressor by soldering
12. Evacuate system
13. Pressure-test system
14. Evacuate system
15. Charge system
16. Test for refrigerant leaks
17. Check unit for normal operation

VI. REBUILD A SEMIHERMETIC COMPRESSOR

Trade Knowledge

References

(3) pp 158-160

1. Knowledge of wrench sizes and use
2. Marking of parts
3. Oil level and grade

Trade Practice Time 6 Hours

Job

Rebuild a semihermetic compressor

Safety

Tools, Equipment, Supplies

1 - Semihermetic compressor
1 - Socket set, 1/2" to 3/4"
1 - 8" screwdriver
1 - Hammer (ball peen, 8 oz)
1 - 8" adjustable wrench
1 - Small center punch
1 - Oil drain can
1 - Gasket set
1 - Armature puller
2 - Piston rod assembly

Procedure

1. Remove plug and drain oil
2. Mark all removable parts with punch
3. Remove bolts from valve plate and cylinder head
4. Remove head and valve plate
5. Remove bolts from end bell (compressor end)
6. Remove motor end bell bolts
7. Remove motor end bell
8. Remove motor armature nut
9. Remove oil sling

10. Pull armature with puller
11. Remove eccentric shaft
12. Remove rods and pistons
13. Replace piston rod assembly
14. Replace eccentric shaft
15. Reverse above procedure and install new gaskets and oil

VII. INSTALL A WINDOW UNIT

Trade Knowledge

References

(2) pp 391-403
(10) RSA #2, Job #2, 3
(5) pp 252-257

1. Exercising care when uncrating units, to prevent damaging of surfaces and parts of unit
2. Interpreting of manufacturer's nameplate data
    a. Voltage
    b. Amperage
    c. NEMA rating
3. Use of hand tools
    a. Power drill
    b. Hand saw
    c. Screwdriver

Trade Practice

Time 1-1/2 Hours

Job

Install a window unit

Safety

Take precautions to avoid damage when fitting heavy unit

Tools, Equipment, Supplies

1 - 1/4" drill
1 - Handsaw
1 - Claw hammer
1 - Level
1 - 6' rule
1 - 2 ft. square
1 - common screwdriver
1 - complete window unit
1 - VOM

Procedure

1. Uncrate air conditioner
2. Check manufacturer's nameplate
3. Remove unit from case
4. Remove shipping blocks from compressor
5. Center and mount case in window
6. Fill in side strips
7. Install weather strips

4. Measuring of window cases and centering of window unit
5. Techniques used for weather stripping
6. Using a VOM to measure voltage
7. Checking wiring from power panel for proper electrical size, proper circuit breaker, etc.

8. Install unit in case

9. Measure voltage at wall outlet
10. Plug power cord in wall outlet and set controls of unit for proper cooling

VIII. MAKE COMPLETE ELECTRICAL CHECK ON WINDOW A/C UNIT

Trade Knowledge

References

(3) pp 1-42 Sec. #1
(10) RSA #2 Job #3,4

1. Use of fuses and circuit breakers as protective devices

2. Use of manufacturers' catalogs and service manual, nameplate data to obtain

   a. Voltage
   b. Amperage
   c. NEMA rating
   d. Btu rating

3. Use of wiring diagrams to make complete electrical checks of units

Trade Practice Time __ Hours

Job

Make a complete electrical check on a window unit

Safety

Take the necessary precautions to prevent electrical shock

Tools, Equipment, Supplies

1 - Window unit
1 - VOM
1 - Screwdriver, 6"
1 - Screwdriver, 6", phillips

Procedure

1. Check fuse or circuit breaker in panel
2. Check fuse in equipment (if applicable)
3. Check manufacturers' nameplate for electrical data

   a. Voltage
   b. Amperage
   c. NEMA rating
   d. Btu

4. Unplug unit, switch to the "on" position (cool), and check for continuity at male plug
5. Check for ground at male plug

	6. Change switch to fan and check male plug for continuity
	7. Plug in unit
4. Checking a unit for correct voltage according to rating on compressor nameplate	8. Check the power source and the voltage at the compressor terminals
5. Use of wiring diagram in troubleshooting a unit	9. Check all wiring visually and compare with published wiring diagram
6. Use of VOM to check compressor motor for grounds and shorts	10. Check the compressor motor for ground by means of continuity check between the common terminal and compressor shell
7. Use of clamp-on type of ammeter to check current flowing through a wire	11. Check fan motor by clamping on one fan-motor wire, using a clamp-on type ammeter
8. Use of nameplate data in analyzing a motor	12. Compare amount of amperage reading on the clamp-on type ammeter with nameplate data
9. Knowledge of fan motor circuit and techniques used to analyze a circuit, using VOM or ammeter	13. If no amperage reading is indicated on the ammeter, disconnect unit from power source and open fan motor circuit from unit and use a VOM to make continuity check on motor winding for grounds, shorts, opens, etc.
10. Overload switches and their purpose a. Internal overload protectors b. External overload protectors	
11. Check of an overload protector a. Making continuity checks on a two-terminal overload b. Making continuity checks on a three-terminal overload	14. Make a continuity check of overload protector on compressor motor (if overload switch is mounted externally)
12. Methods of checking the different types of relays a. Current-type relay b. Potential relay	15. Check relays, using VOM and refer to the wiring diagram for technical information about the relay
13. Types of capacitors used on compressor motors and fan motors	16. Use a VOM to check the capacitor on the compressor and fan motor (if applicable)
14. Methods of checking a capacitor with VOM or a capacitor checker	17. Check all work for completeness and place unit in operation

IX. ADD A COOLING SYSTEM TO EXISTING HEATING UNIT

Trade Knowledge

References

(10) RSA #5, Job #14
(5) pp 266-270

Trade Practice Time 30 Hours

Job

Add a cooling system to presently existing heating system with ducts

SAFETY

Do not weld on system under pressure. Make sure switch panel is dead before wiring

Tools, Equipment, Supplies

1 - Cooling coil
1 - Thermostatic expansion valve, 3-ton, F-22
1 - Liquid indicator
1 - Dryer
1 - Solenoid valve
1 - 3-hp, air-cooled condensing unit
1 - Heat and cool thermostat
5/8" copper tubing
3/8" copper tubing
5/8" sponge-rubber insulation
1 - Evaporator rack
1 - Fan relay
3-wire (8-gage)
3/4" thin-wall conduit
2 - 3/4" connectors
6 - Couplings
Freon-22
Nitrogen
1 - Heating unit (existing)
1 - Pair tin snips
1 - Level, 2 inch
1 - Carpenter's square
1 - Claw hammer
1 - Ratchet wrench, 3/8" drive with sockets 1/2" through 3/4"
1 - Flare nut wrench, 3/4" - 1"
1 - Flare nut wrench, 7/8" - 1-1/8"
1 - Adjustable wrench, 12"
1 - Adjustable wrench, 8"
1 - Pair pliers 6"
1 - Pair diagonal pliers, 6"
1 - Phillips screwdriver, 6"
1 - Common screwdriver, 6"
1 - Conduit bender 3/4"

1. Procedure for setting evaporator basic duct work
2. Use of manufacturers' data for mounting evaporator

    a. Mounting information
    b. Duct installation
    c. Wiring installation

3. Planning a run of pipe from evaporator to condenser
4. Brazing, soldering, bending, and cutting pipe
5. Proper location for

    a. Solenoids
    b. Expansion valves
    c. Liquid line solenoid

6. Methods of running EMT
7. Operation of heat and cool thermostat
8. Proper locations for mounting thermostats
9. Use of electronic leak detector
10. Types of wires used in heating- and cooling-control systems
11. Use of VOM to check

    a. Continuity
    b. Voltage
    c. Resistance

1 - Manifold gage set with changing hose
1 - Vacuum pump
1 - Oxyacetylene torch
1 - Stan drill, 3/4"
1 - Ball peen hammer, 1-16
1 - Hand brace
1 - 3/8" bit
1 - Valve ratchet wrench

Procedure

1. Set evaporator in duct above heating unit
2. Set condensing unit on concrete slab
3. Install gages on compressor and manifold
4. Run suction line from condenser to evaporator and braze and solder
5. Set solenoid on evaporator
6. Set sight glass and dryer on condenser
7. Run liquid line from evaporator and solenoid to condenser
8. Pressure test at 250 psi with a mixture of nitrogen and F-22
9. Check with leak detector and soap bubbles
10. Repair any leaks
11. Evacuate and dehydrate system; maintain vacuum while wiring system
12. Throw switch at power panel
13. Run conduit from switch to condensing unit
14. Pull wires from panel to condenser, connect at wires
15. Use ohmmeter to make continuity and ground checks
16. Run 1/2" conduit from condenser through wall to panel on heater

12. Use of wiring diagram for proper installation and connection to relay
13. Use of manufacturer's published wiring diagram to install complete unit wiring system
14. Charging a central cooling system

17. Install fan relay (consult wiring diagram for proper connections)
18. Replace thermostat with heat and cool thermostat
19. Charge out wiring for thermostat

20. Connect control system
21. Charge through unit

22. Check all work for completeness
23. Place system in operation and check heating and cooling operation

X. THERMOSTATIC CONTROL (WALL MOUNTING TYPE)

Trade Knowledge

References

(1) pp 526-530

1. Types of thermostatic controls: electrical, pneumatic, and electronic
2. The function of thermostatic control: to sense and control airflow temperature
3. Method of operation of the thermostatic control

    a. Gas expansion and contraction against diaphragm in filler bulb
    b. Adjustment in or out varies spring tension against diaphragm which act on points

Trade Practice Time 2 Hours

Job

Check, calibrate or replace thermostatic control

Safety

Take necessary precaution to prevent electrical shock

Tools, Equipment, Supplies

1 - Central air-conditioning unit
1 - Thermometer
1 - 1-1/ 2" screwdriver
1 - 6" screwdriver
1 - VOM

Procedure

1. Remove one wire and check continuity through the thermostat control in "off" position and in the "on" position

4. Adjustment differential corrected by turning a screw in or out
5. Use of manufacturers' catalogs and service manuals to obtain

   a. Specification
   b. Amperage
   c. Voltage
   d. Thermostat range
   e. Differential
   f. Other

6. Explanation of wiring diagram with thermostat control included

2. Check the temperature of the return airstream with a thermometer
3. Remove end plate and turn range-plate screw for higher or lower temperature

4. Make adjustment of differential screw to affect cut-in temperature

5. Check to see that filler bulb is in the return airflow

6. If control is faulty, unscrew and replace

XI. CHECK CFM, CLEAN CONDENSER AND EVAPORATOR

Trade Knowledge

Reference

(10) Job #7, 10

1. Use of velocity meter
2. Use of cleaning fluid
3. Use of Anemometer

Trade Practice Time 2 Hours

Job

Check cfm; clean condenser and evaporator

Safety

Tools, Equipment, Supplies

1 - Operating A/C system (aircooled)
1 - Velocity meter
1 - Cleaning fluid
1 - Spray tank
1 - Garden hose
1 - Air hose
1 - Anemometer

Procedure

1. Check cfm
2. Check filter and fan
3. Cover all electrical parts with paper or plastic
4. Spray cleaning fluid on evaporator and condenser coils
5. Use garden hose to rinse off
6. Blow off water with air

XII. CHARGE A CENTRAL SYSTEM

Trade Knowledge

References

(1) p 215, 219, 278-284

1. Installation of manifold gages
2. Reading of manifold gages
3. Operation of low-side and high-side cut-out switch
4. Correct operating pressures for each refrigerant
5. Putting nitrogen in a system as a vapor or as a liquid

Trade Practice

Time: 12 Hours

Job

Charge a central system

Safety

Tools, Equipment, Supplies

1 - Manifold gage set
1 - Valve wrench
1 - Vacuum pump
1 - Manometer
1 - Refrigerant hose
1 - A/C unit (central unit for residential use)
1 - 8" adjustable wrench
1 - 6" Screwdriver (flat blade)
- Refrigerant
- Nitrogen

Procedure

1. Install manifold gage to valve ports; check valve ports for proper position
2. Evacuate system
3. Select refrigerant to match unit
4. Run line from refrigerant tank to manifold gage
5. Put in approximately half the capacity of liquid on the liquid side of the compressor
6. Turn switches on

   NOTE: Unit will not start because of low-side cutout

7. Put vapor in on suction side of compressor until unit starts; continue adding until sight glass clears
8. Align valves and remove gage manifold

XIII. THERMOSTATIC EXPANSION VALVE

Trade Knowledge

References

(1) pp 77-78
(2) pp 224-228
(7) RSA 18, Job 17

1. Installation of pressure gages
2. Technique of opening testing gages to prevent damage to the gage from high pressures
3. Low back pressure - power element failure in thermostat
4. Pumping down of a refrigeration system
5. Types of thermostatic expansion valve
    a. Constant pressure valve
    b. Constant superheat

Trade Practice

Time 4 Hours

Job

Check thermostatic expansion valve

Safety

Use safety goggles when working with refrigerants

Tools, Equipment, Supplies

1 - Central air-conditioning system
1 - Manifold gage set, with hoses
1 - Valve ratchet wrench
1 - Adjustable wrench, 12"
1 - Adjustable wrench, 8"
1 - Flare nut wrench, 7/8" x 1-1/8"
1 - Flare nut wrench, 3/4" x 1"
1 - Screwdriver (standard) 10"
1 - Screwdriver (standard) 6"
1 - Phillip screwdriver, 6"
1 - Drum F-22 refrigerant

Procedure

1. Remove access panel on condensing unit
2. Install gages on compressor
3. Open service valve to obtain gage reading
4. Check operating pressure
5. Remove side panel from air-conditioner unit
6. Install gages on compressors
7. Open service valve 1/4 turn from back seat to obtain gage reading
8. Close liquid receiver valve
9. Pump down system to approximately 1/2-pound lowside pressures
10. Stop compressor

6. Purpose of automatic expansion valve

   a. To restrict the flow of the refrigerant from the low to the high side
   b. To regulate the refrigerant flow according to the needs of the system

7. Location of expansion valve on most units

8. Construction of automatic expansion valve and function of each point

   a. The thermal bulb
   b. Bellows
   c. Adjusting screw
   d. Spring
   e. Valve seat
   f. Valve stem
   g. Inlets and outlets

9. Function of automatic expansion valve
10. Starting a unit and making checks to see that the unit is operating properly

11. Remove thermostatic expansion valve and replace with new one

12. Open liquid service valve and allow pressure to build to 25 lbs. on compound gage
13. Close liquid valve

14. Open low side of manifold; allow pressure to escape to zero pounds of pressure
15. Close low side of manifold valve
16. Check all work for completeness. Place unit in operation and check for proper function

A WORD OF EXPLANATION

One of the major purposes of this publication is the identification of the content of the trade. To this end, a trade analysis is given in the Appendix.

The greater portion of this publication is a detailed treatment of the principles and practices of the refrigeration, air-conditioning trade. An examination of the content will reveal that the treatment of these principles and practices, called a course outline, carefully parallels the analysis in the Appendix.

Because of time limitation, the course has been only partially completed. The total guide will include both domestic and commercial refrigeration, air conditioning, and heating, requiring 2180 hours of instruction. The portion of the guide presented herein identifies the major portion of the content to be taught in the first 1080 hours. The instructor is encouraged to carefully examine the completed portion and to develop his own further course of study, using the analysis as a guide.

At a later date, the Laboratory will schedule workshops and lend technical assistance to instructors in developing additional instructional materials. All materials developed in the future will use this guide as a starting point.

APPENDIX

RECOMMENDED TEXTS AND KEY TO INSTRUCTOR'S REFERENCES

RECOMMENDED TEXT:

either

Althouse, Andrew D., and Carl H. Turnquist. Modern Refrigeration and Air Conditioning. Homewood, Illinois: The Goodheart-Willcox Company, Inc., 1960.

______________. Shop Job Sheets (to be used with the book Modern Refrigeration and Air Conditioning by Althouse and Turnquist). Homewood, Illinois: The Goodheart-Willcox Company, Inc.

or

Lang, Paul V. Principles of Air Conditioning, rev. ed. Albany, New York: Delmar Publishers, Inc., 1964. (Instructor's Guide under separate cover)

Marsh, R. Warren, and C. Thomas Olivo. Principles of Refrigeration. Albany, New York: Delmar Publishers, Inc., 1964. (Instructor's Guide under separate cover)

KEY TO INSTRUCTOR'S REFERENCES:

1. Althouse, Andrew D., and Carl H. Turnquise. Modern Refrigeration and Air Conditioning. Homewood, Illinois: The Goodheart-Willcox Company, Inc., 1960.

2. Anderson, Edwin P. Audels Home Refrigeration and Air Conditioning Guide. Indianapolic, Indiana: Howard W. Sams & Company, Inc., 1966.

3. Doolin, James H. Doolin's Trouble Shooters Bible. Dallas, Texas: Doolco, Inc. 1963.

4. Goliber, Paul F. Refrigeration Servicing (Lab Manual). Albany, New York: Delmar Publishers, Inc., 1960.

5. Lang Paul V. Principles of Air Conditioning. Albany, New York: Delmar Publishers, Inc., 1961.

6. ______________. Instructor's Guide for Principles of Air Conditioning. Albany, New York: Delmar Publishers, Inc., 1965 rev.

7. Louisiana State Vocational-Technical Schools. Refrigeration and Air Conditioning, Unit I - Related Study Assignments; Unit I - Job Sheets; Unit I - Mathematics. Natchitoches, Louisiana: Louisiana State Vocational-Technical Curriculum Laboratory, 1962.

8. ______________. Refrigeration and Air Conditioning. Units II & III - Related Study Assignments; Units II & III - Job Sheets; Units II & III - Mathematics. Natchitoches, Louisiana: Louisiana State Vocational-Technical Curriculum Laboratory, 1962.

9. ______________. Refrigeration and Air Conditioning. Unit IV - Related Study Assignments; Unit IV - Job Sheets; Unit IV - Mathematics. Natchitoches, Louisiana: Louisiana State Vocational-Technical Curriculum Laboratory, 1962.

10. ______________. Refrigeration and Air Conditioning. Unit V - Related Study Assignments; Unit V - Job Sheets; Unit V - Mathematics. Natchitoches, Louisiana: Louisiana State Vocational-Technical Curriculum Laboratory, 1962.

11. Marsh, R. Warren, and C. Thomas Olivo. Principles of Refrigeration. Albany, New York: Delmar Publishers, Inc., 1960.

12. ______________. Instructor's Guide for Principles of Refrigeration. Albany, New York: Delmar Publishers, Inc., 1960.

13. Rosenberg, Robert. Electric Motor Repair. New York: Holt, Rinehart and Winston, 1965.

14. Carr, Clifford C., and Terrell Croft (1913-1921), eds. American Electricians' Handbook. 8th ed. (text ed.) New York: McGraw-Hill Book Company, Inc., 1961.

BASIC MATHEMATICS

I. ARITHMETIC

A. Whole numbers

1. Addition of whole numbers
2. Subtraction of whole numbers
3. Multiplication of whole numbers
4. Division of whole numbers

B. Fractions

1. Addition of common fractions
2. Subtraction of common fractions
3. Multiplication of common fractions
4. Division of common fractions

C. Decimal fractions

1. Addition of decimal fractions
2. Subtraction of decimal fractions
3. Multiplication of decimal fractions
4. Division of decimal fractions

D. Measurements

1. Linear measure
2. Angular measure
3. Circular measure
4. Area
5. Volume

E. Percentage

1. Finding the percent of numbers
2. Application of percentage
3. Averages
4. Estimates
5. Percentage of simple finance
6. Use of percentage in manufacturing and cost

F. Graphs

1. Bar graphs
2. Line graphs
3. Circle graphs

G. Symbols

1. Addition of symbols
2. Subtraction of symbols
3. Multiplication of symbols
4. Division of symbols

H. Equations

1. Concept of positive and negative numbers
2. Solving equations by addition
3. Solving equations by subtraction
4. Solving equations by multiplication
5. Solving equations by division

I. Formulas - application as applied to

1. Rectangles
2. Squares
3. Circles
4. Fundamental electricity

J. Geometry of lines and shapes

1. Lines
2. Angles
3. Circles
4. Basic solid and flat shapes

RELATED SUBJECT MATTER

PHYSICS

I. MATTER

- A. Structure of matter
  - 1. Atoms
  - 2. Molecules
- B. Physical state of matter
  - 1. Solid
    - a. Density of copper
    - b. Density of aluminum
    - c. Density of steel
  - 2. Liquid
    - a. Special properties of liquids
      - (1) Under pressures
      - (2) Under different temperatures
    - b. Specific gravity
      - (1) Water
      - (2) Acids
      - (3) Oils
  - 3. Gas
    - a. Special properties of gas
      - (1) Under pressure
      - (2) Under temperatures differentials
    - b. Density of gases
    - c. Gas laws

II. MEASUREMENT

- A. English system
  - 1. Linear
    - a. Inches
    - b. Feet
    - c. Yards
  - 2. Area
    - a. Square inches
    - b. Square feet
    - c. Square yards

- 3. Volume
    - a. Cubic inches
    - b. Cubic feet
    - c. Cubic yards
- B. Metric system
  - 1. Linear
    - a. Centimeter
    - b. Meter
  - 2. Area
    - a. Square centimeters
    - b. Square meters
  - 3. Volume
    - a. Cubic centimeters
    - b. Cubic meters

III. FORCES

- A. Kinds of forces
- B. Effects of forces
- C. Mechanical advantages
- D. Work, power, and efficiency of motors
- E. Balance and equilibrium
- F. Vectors

IV. SIMPLE MACHINES

- A. Levers
  - 1. Hand tools
  - 2. Mechanical advantage applied
  - 3. Industrial use of simple machines
- B. Inclined planes
  - 1. Mechanical advantages
  - 2. Wedges as tools
- C. Wheels and axles
- D. Screw threads
  - 1. Terms and uses
  - 2. Force and motion of screws
- E. Simple and compound
  - 1. Pulley for electric motors
  - 2. Vises and clamps

F. Power
  1. Power transmission
    a. Belts, V-belt drives
    b. Coupling
  2. Power measurements
    a. Prony brake
    b. Horsepower calculations

G. Friction
  1. Causes and types
  2. Coefficients of friction
  3. Reducing friction

H. Lubrication
  1. Types of lubrication
    a. Gravity
    b. Pressure
    c. Splash
  2. Types of lubricants

V. HEAT

A. Sources of heat
  1. Solar (sun rays)
  2. Electrical
  3. Atomic
  4. Frictional
  5. Other

B. Measurement of heat
  1. Specific heat
  2. Latent heat
    a. Fusion
    b. Evaporation

D. British thermal unit (Btu)
E. Transfer of heat
  1. Radiation
  2. Conduction
  3. Convection
  4. Evaporation

F. Boiling points of liquids and gases
  1. Refrigerant 12
  2. Refrigerant 22
  3. Alcohol
  4. Water

G. Effects of pressure on boiling points of liquids
H. Change of state of heat as in refrigerators

VI. CHEMISTRY

- A. Structure of matter
  - 1. Elements
    - a. Oxygen
      - (1) Common element
      - (2) Combustion
      - (3) Properties
    - b. Others
  - 2. Compounds and mixtures
- B. Physical state
  - 1. Solid
  - 2. Liquid
    - a. Solution
    - b. Suspension
  - 3. Gas
- C. Physical and chemical change of matter
- D. Acids, bases, and salts
  - 1. Use of acid
  - 2. Use of bases
- E. Acids and metals
- F. Neutralization
- G. Ferrous and nonferrous metals
  - 1. Ferrous
    - a. Iron
    - b. Steel
    - c. Nickel
    - d. Other
  - 2. Nonferrous
    - a. Aluminum
    - b. Copper
    - c. Brass
    - d. Other
- H. Corrosion
  - 1. Effects on ferrous metals
  - 2. Effects on nonferrous metals

ANALYSIS

UNIT I. FUNDAMENTALS AND GENERAL SHOP

1. Cut and thread pipe
2. Flare and swage copper tubing
3. Use electrical meters and test lights
4. Use halide and electronic leak detectors
5. Use thermometer to measure temperature
6. Use manifold gages
7. Fabricate tubing and identify refrigeration fittings
8. Soft-solder joints
9. Silver-solder joints
10. Weld pipe with oxyacetylene
11. Cut metal with oxyacetylene
12. Weld flat metal with oxyacetylene
13. Install single-phase service entrance
14. Install circuit breakers
15. Install circuit fuses
16. Repair or replace solenoid valves
17. Install, repair, or replace thermostats
18. Replace or repair rectifiers
19. Check and/or replace relay
20. Install wall outlet
21. Run conduit
22. Connect control systems to high and low voltage
23. Service or make minor repairs on split-phase motor
24. Service or make minor repairs on capacitor motor

25. Service or make minor repairs on capacitor-start motor

26. Service or make minor repairs on capacitor-start and capacitor-run motors

27. Service or make minor repairs on repulsion types of motors

28. Service or make minor repairs on 2-phase motor

29. Service or make minor repairs on 3-phase motor

30. Service or make minor repairs on manual starters

31. Service or make minor repairs on automatic starters

32. Reverse rotation of various types of motors

33. Change voltage of dual motors

34. Clean, oil, and maintain electrical motors

UNIT II. DOMESTIC REFRIGERATION

A. Conventional domestic refrigeration

1. Evacuate a domestic unit
2. Charge an open-type domestic system
3. Charge a sealed-type domestic system
4. Install and check a domestic unit (electric)
5. Install and check a domestic unit (absorption)
6. Locate and repair refrigerant leaks in domestic units
7. Replace a hermetic compressor
8. Repair and/or replace an automatic expansion valve
9. Test, remove, and/or repair a capillary-tube refrigerant control
10. Test, remove, and/or repair a thermostatic expansion valve
11. Charge a service cylinder from a storage cylinder
12. Repair bimetal temperature controls
13. Repair thermostatic temperature control
14. Test and/or minor repair motors
15. Install a dryer
16. Test and/or replace a starting hot-wire relay
17. Test and/or replace a starting current relay
18. Test and/or replace a starting potential relay
19. Test, repair and/or replace hot-gas defrost
20. Test, repair and/or replace electric defrost
21. Check, test, and repair automatic ice maker
22. Check the electrical system on refrigeration unit (from plug through motor)
23. Install door seals and adjust door of domestic units

B. Domestic absorption refrigeration

1. Adjust the gas regulator
2. Install an absorption refrigerator
3. Install electric heating element
4. Adjust and/or repair automatic control valves (thermocouple pilot operated)
5. Check and/or replace thermostat
6. Clean and adjust baffles on flue
7. Troubleshoot and/or repair automatic defroster
8. Service automatic ice maker

UNIT III. RESIDENTIAL AIR CONDITIONING

A. Window units

1. Install window units
2. Install a service-valve attachment
3. Make electrical checks of motors on air-conditioning units containing different types of electric motors
4. Check the relay on a hermetic unit
5. Test and/or replace a capacitor on a hermetic unit
6. Check the refrigerant charge on a hermetic unit
7. Troubleshoot a capillary-tube system on a hermetic unit
8. Replace a hermetic compressor
9. Make electrical checks on fan motors
10. Rebuild a semihermetic compressor
11. Check CFM and clean condenser and evaporator
12. Check, calibrate, or replace thermostatic control
13. Make a complete electrical check on a complete window unit

B. Central systems

1. Add a cooling system to presently existing heating system with ducts

2. Check and repair mechanical failures in central systems

3. Troubleshoot the electrical circuits of central systems

4. Evacuate an air-conditioning system

5. Charge a central-unit system

C. Controls

1. Install, test, and/or replace winter-summer switch over controls

2. Install, test, and/or replace day and night controls

3. Install, test, and/or replace a thermostat control

D. Water towers

1. Treat water

2. Repair water pumps

3. Adjust, repair, or replace float

4. Clean spray nozzles

5. Check and repair forced-draft mechanism

6. Clean and repair air-cooled condenser

EQUIPMENT LIST

Care should be taken when ordering the equipment in the following list so that control valves, expansion valves, and other parts will be applicable to the major units involved in the training program.

The central heating unit, and split-cooling unit with evaporator coils and controls should all be integrated so that they can be used separately or in conjunction with each other.

All tools, equipment, and supplies should be of high quality and backed by a reputable manufacturer's guarantee.

HAND TOOLS

Quantity	Item
4	Torches: Kit
1	Torch: Welding and cutting outfit
5	Wirebrushes: Wire bristle brush
1 set	Screwdrivers: Round-shank, flat-blade, 3", 6", 8", 10", 12", 18" in length
1 set	Screwdrivers: Square shank, 6", 8", 10", 12", 18" in length
1 set	Screwdrivers: Phillips, #1, #2, #3; 3", 6", 8", 10", 12" in length
5	Pinch-off tools: Pinch-off pliers
5	Hammers: Ball peen; 8 oz., 12 oz., 18 oz., and 24 oz.
5	Center punches
1 set	Pullers: Gear
1	Bender: Conduit, 1/2" thin-wall
1	Bender: Conduit, 3/4" thin-wall
1	Pipe Cutter: 1/4" to 1"
1	" " 1" to 8"
1 set	Taps and dies: NF and NC thread
5	Trisquares
2	Wrenches: Pipe, heavy-duty, 8"
2	" " " " 14"
5 sets	Swaging tools: 1/4" to 5/8"
4	Wrenches: Nut driver set, 3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8"
5	Pliers: Combination
5	Vise grips: Straight jaw
5	Pliers: Utility, heavy-duty
5	Hammers: Soft head

Quantity	Item
5	Wrenches: Adjustable, 8"
5	Wrenches: Adjustable, 10"
1	Level: 2 ft. in length
3 each	Wrenches: Service valve ratchet wrench, reversible; 1/4", 3/8", 5/16"
4	Arc strikers
1	Wrench: Auto-flare, set of 1/2", 9/16", 3/8", 3/4", 1", 1-1/4", 1-1/2"
5	Soldering irons: Heavy-duty, 250 watts
5	Wire strippers
5	Wire cutters: 9" side cutters
5	Wire cutters: 7-1/2" diagonal with plastic grip
5	Pliers: Needle-nose, 6-3/4" with plastic grip
2	Wire gages
5	Measuring tapes: 12' in length
4	Vise: 5" jaw width
1	Vise: 6" jaw width
5	Flaring kits: 1/8" to 3/4", flaring tool kit
2	Flaring kits: 1/4" to 3/4", double flaring tool kit
2 sets	Bender: Tubing, from 1/4" to 7/8"
5	Hacksaws: Adjustable for 8", 10", 12" blades
3 Dozen	Hacksaw blades: 1 doz 8", 1 doz. 10", 1 doz. 12"
4	Cutters: Tubing, 1/4" to 1-3/8"
1 set	Calipers: Inside, for measuring cylinder sizes
1 set	Micrometers: 0-1", 1" - 2", 2" - 3", 3" - 4"; graduated in thousanths
5	Files: Mill, 8" long
1 set	Drill bits: Fractional drill set with holder, 1/16" to 1/2" by 32nds

Quantity	Item
1 set	Socket wrenches: 1/4" square drive socket wrench handles and attachments; sockets, 6-point, 3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8", 7/16" openings; sockets, 8-point, 1/4", 5/16", 3/8", opening; socket, 12-point, 1/2" opening; ratchet; extension 2" & 6"; sliding bar handle all in metal box
1 set	Socket wrenches: 3/8" square drive socket wrench handles and attachments; sockets, 12-point, 3/8", 7/16", 1/2", 9/16", 5/8", 11/16", 3/4" opening ratchet; extension bar 3-1/2" x 12" long; hinge handle; special handle; and metal box
1 set	Socket wrenches: 1/2" square drive socket wrench handles and attachments; socket 12-point, 7/16", 1/2", 9/16", 19/32", 5/8", 11/16", 3/4", 25/32", 13/16", 7/8", 15/16", 31/32", 1", 1-1/16", 1-1/8", 1-3/16", 1-1/4" opening; ratchet 10" long; extension bars, hinge handle; steel box
2 sets	Wrenches: Combination open end, box end, 5/16", 3/8", 7/16", 1/2", 9/16", 5/8", 11/16", 3/4", 3/16", 7/8", 15/16", 1", 1-1/16", 1-1/8" 1-1/4" opening
2	Handsaws: 12-point
2	Squares: Framing square

POWER TOOLS

1	Drill: 1/2" electric, reversible, 115-volt
2	Drills: 1/4" electric, 115-volt, variable speed
1	Key saw: Electric, 115-volt, two-speed
1	Spray tank
1	Air compressor: 5-hp, 220-volt, 3-phase
1	Drill and stand: 3/4", drill with floor stand
1	Cleaning vat: For cleaning parts
1	Grinder and stand: 7" grinder, with safety shields, floor stand, 115/230 volt motor, one fine grinding wheel and one coarse grinding wheel

3

METERS

Quantity	Item
5	Multimeters: 20,000 ohms per volt DC,5,000 ohms per volt AC 10, 100, 500 MA, 10 amp, 0-3000 volt DC and AC
5	Ammeters: 0-15 amps
5	Wattmeters: 0-5000 watts
5	Meters: Clamp-on-type, amp range AC 0-15/40/30, volt range AC 0-150/300/600
2	Voltage testers: a-c and d-c, 0-600 volts
1	Capacitor checker: 1 to 2000 mfd, with Prest-O-test safety feature
2	Tachometers: 100 to 4000 rpm, with two tips, one for measuring flat shafts and one for shafts having a center hole and one for measuring speed of flat shafts, pulley, etc.
2	Manometers
1	Leak tester: Electronic
1	Thermometer
1	Thermometer: Bimetallic dial, -35° to 75°F.
1	Thermometer: Freezer, -40° to 60°F.
1	Thermometer: for general purpose testing, refrigeration, heating, calibrated for total immersion; 5-1/2" long
2	Velocity meters
1	Dolly: Household
4	Refrigeration units: used but operable
4	B-Tanks
2	Hermetic accessible kits: Service kits
4	Dryers: Filter dryers, assorted 1/4" to 3/8" flare or equal
2	Acid kits: Cleanout kit
1	Compressor: 1/6 hp, 115-volt, refrigerant F-12, with matching starting relay
	Expansion valves: Assorted

Quantity	Item
1	Automatic expansion valve
2	Temperature controls: Bimetal
4	Temperature controls: Thermostat
2	Test kits: Relay test kits
2	Defrost controls: Automatic defrost control
2	Timers: Defrosting timers
* 1	Central heating unit: Electric, 110/220 volt, with fan section
* 1	Air conditioning evaporator coil: Uncased, coil to fit carrier unit above
* 1	Air conditioning condensing unit: 2-ton capacity, air-cooled, 220 volt
1	Quick coupling yoke
5 sets	Gages: Manifold, complete set of gages with yellow jacket hose
1	Vacuum pump: Portable charging station
1	Vacuum pump: 0.1 micron, high vacuum pump
1	Vacuum pump gage: High vacuum gage
1	Vacuum pump test manifold: Hi-vac-test manifold
1	Demonstrator unit
1	Domestic absorption refrigeration unit
	REFRIGERATION EQUIPMENT
1	Hose: Flexible
3	Vacuum pumps: pump down to 29.62 inches of mercury; unit to include manifold gages and 3' charging lines
5	Hermetic unit analyzers: 110/220-volt

* These units should be purchased so that they can be used in combination with each other in a training program.

Quantity	Item
1	Cylinder: 25# drum, F-12
1	Cylinder: 50# drum, F-22
1	Cylinder: 145# drum, F-12
1	Cylinder: 125# drum, F-22
3	Refrigeration units: open-type, 1/3-hp, 115/230-volt, F-12 with evaporator and controls to match
3	Refrigeration units: open-type, 1/3-hp, 115/230-volt, with evaporator and controls to match unit
3	Evaporators: Units should be applicable to above units
1	Refrigeration unit: Open-type, water-cooled
3	Air conditioning units: Window unit, complete 12,000 Btu
3	Air conditioning units: Window unit, complete 18,000 Btu
3	Compressors: Compressor to be applicable for replacement of 12,000 Btu window unit above
3	Compressors: Compressor to be applicable for replacement of 18,000 Btu window unit above
10 each	Tap-a-line valves: 1/4", 3/8", 5/16", 1/2",
5 each	Control valves: For tap-a-line valves for 1/4", 5/16", 3/8", 1/2", 5/8" pipe
* 1	Thermostat and base: Control for above units
1	Drum nitrogen: 244 cubic feet
1 set	Regulators: For dry nitrogen, to 4000 lbs., regulator from 0-50 lbs.
1	Heat pump: 2-ton with 25-kw heating strips
	Gaskets: Gaskets applicable for training units that are to be used
	Silver solder
2	Silver solder flux: 6-ounce bottles
	Couplings: Sweat assorted from 1/4" to 1-1/8"
5	Oil cans: Flexible spout
2 gals.	Cleaning fluid

Quantity	Item
	Hose: Garden, 5/8" dia.
	Hose: Air, 50' long
	Insulation: Rubber sponge, 50' long
	Conduit: 1/2" EMT, 100' long
	Conduit: 3/4" EMT, 100' long
12	Connectors: 1/2" for EMT
12	Connectors: 3/4" for EMT
12	Couplings: 1/2" for EMT
12	Couplings: 3/4" for EMT
	Resistors: 1-ohm, 50-watt
	Resistors: 4-ohm, 50-watt
	Resistors: 10-ohm, 50-watt
	Resistors: 25-ohm, 50-watt
	Resistors: 50-ohm, 50-watt
	Resistors: 100-ohm, 50-watt
	Resistors: 200-ohm, 50-watt
	Resistors: 500-ohm, 50-watt
	Resistors: 1000-ohm, 50-watt
	Resistors: Composition, assorted group from 15 ohms to 1500 ohms, 2 watts
	Capacitors: Assorted, 5 mfd, 270 volts, oil capacitor
	" " 25 " 270 " " "
	" " 35 " 270 " " "
	" " 130-170 " 270 " dry electrolytic
	" " 180-230 " 270 " " "
	Capillary tubing: 50' of .032 tubing
	Capillary tubing: 50' of .036 tubing
	Scales: Weight to 150 lbs. calibrated in ounces

MISCELLANEOUS

Quantity	Item
5	Coils: Solenoid valve, 1/2" opening, 24-volt coil, DPST with 25-amp contacts
1	Wire: 5-lb. roll, #28 coated wire for winding coils
1	Wire: 5-lb. roll, #34 coated wire for winding coils
5	Relays: SPST, 115-volt coil, 15-amp contacts
5	Relays: DPST, 115-volt coil, 15-amp contacts
5	Relays: DPDT, 115-volt coil, 15-amp contacts
4	Solenoids: 115-volt, 115-volt coil, design for refrigerant 12, 22, 500 and water
1 pack	Relay: Potential type
3	Relays: Hot-wire type
2	Relays: Current, motor-starting relays
Assorted Fittings	
5 rolls	Solder: 60/40
	Couplings: 1/4", 3/8", 1/2", 3/4", 1/16"
	Reducers: 1/4: x 3/8", 1/4" x 5/16", 1/4" x 1/2", 1/2" x 3/4"
	Tees: 1/4" x 1/4" x 1/4", 1/2" x 1/2" x 1/2", 3/8" x 3/8" x 3/8", 1/4" x 3/8" x 1/2"
	Steel wool: assortment
	Sandpaper: assortment
5	Extension cords: 50' long, #12-3 wire
10 pair	Goggles: Clear
5	Drop cloths
5	Arc strikers
	Sand cloths: Assortment
	Wire: Copper, 100' roll, #12 Wire: Copper, 100' roll, #14 Wire: Copper, 100' roll, #16
4 boxes	Terminals: Assorted electrical terminals

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